# Chapter 2 CONTENTS OF THE PROJECT

## 2-1 Basic Concept of the Project

Project objectives of the Basic Design Study are to attain achievement of stable water supply throughout the year by developing new groundwater sources and establishment of the water supply block through improvement of water transmission and distribution pipe network, which will enable adequate operation and maintenance and contribute to reduction of unaccounted-for water.

To achieve the objectives of the Project,

- development of new groundwater sources,
- improvement of water transmission and distribution system and establishment of water supply block, and
- provision of metering system to enhance quantity monitoring in each water supply block

will be implemented. Unstable water supply condition during dry season will be improved by the Project and people will be able to receive stable water supply throughout 24 hours. Contamination of water in distribution system will be avoided because of uninterrupted pressured water supply. Establishment of metering system in each water supply block will facilitate effective implementation of unaccounted-for water reduction measures.

Water shortage in central highland area has been serious and groundwater development in these area has not been successfully completed. Groundwater development under the Project will improve water supply condition remarkably and this technical experience will extend to the other area where has same problem.

The scope of the Project includes:

- Construction of wells,
- Installation of water transmission pipelines,
- Installation of distribution mains, and
- Construction of service reservoirs.

In addition to the above, procurement of water meters for replacement of existing defective meters and a meter test bench for meter calibration are also included in the project scope.

## 2-2 Basic Design of the Requested Japanese Assistance

### 2-2-1 Design Policy

#### 2-2-1-1 Existing Condition of Water Supply System and Scope Requested by the GOSL

Water supply system in Nuwara Eliya depends its source on nine (9) surface water sources. Water quality of these surface water sources is generally satisfactory and the water is supplied to people after disinfection only. Water from intake is supplied generally by gravity via service reservoir except small-scale booster pumping for some remote area or high elevation area. During rainy season, when turbidity of the surface water increase for short period, water is distributed after filtration by existing pressurized filter and disinfection. Served population is about 28,500 in year 2000 and the service ratio is 77%.

The most serious problem encountered by the Nuwara Eliya water supply system is surface water shortage during dry season. Usually the dry season lasts for five (5) months from January to May and yield of the surface water will decrease to 30% of that of the rainy season and reaches 10% during severe drought year. Water shortage during the dry season is aggravated by increasing number of tourists. Nuwara Eliya is one of the famous summer resort and tourists concentrate during dry season. To cover the shortage, groundwater is also supplied but the quantity is far small to overcome the shortage. Water balance between water available in dry season and demand in 2000, 2005 and 2015 which were estimated by the previous JICA Study are shown in **Table–2.1**

**Table-2.1 Water Balance, Demand and Water Source in Dry Season ($m^3$/day)**

| | Quantity of Water Source | | Year 2000 | | Year 2005 | | Year 2015 | |
|---|---|---|---|---|---|---|---|---|
| | Rainy Season | Dry Season | Demand | Shortage in Dry Season | Demand | Shortage in Dry Season | Demand | Shortage in Dry Season |
| Surface Water Source | 18,000 | 3,345 | | | | | | |
| Groundwater Source | - | 900 | | | | | | |
| Total | 18,000 | 4,245 | 9,800 | 5,555 | 10,200 | 5,955 | 10,700 | 6,455 |

Another problem area is the complicated water distribution system. Water transmission mains and distribution mains are connected to plural number of water intakes and service reservoirs. These complicated piping systems are hampering appropriate water supply control as required. Thus, quantity of unaccounted-for water cannot be evaluated since quantity of water distributed is not measured.

Especially at the exiting intakes, Old Water Field and Pedro, operation of the water supply is very difficult since there are no service reservoirs to cope with the fluctuating water demand.

To overcome these current problems, the GOSL requested to GOJ for implementation of the Phase 1 Project which was identified by the previous JICA Study as grant aid project in June 1999.

Scope of the requested project is as follows:

- Development of new groundwater sources, construction of seven (7) wells with pumps
- Installation of groundwater transmission pipes (L = 6,260m)
- Installation of surface water transmission pipes (L = 6,900m)
- Installation of distribution pipes (L = 10,911m)
- Construction of six (6) service reservoirs
- Procurement of seven (7) sets of bulk meters

#### 2-2-1-2 Water Supply System Design Concept

Water supply system design concept employed by the Basic Design Study is as follows:

- Following results and concepts of the previous JICA Study after confirmation considering current situation
- Quality of water distributed should be potable
- Project target year is 2005. Transmission pipes, service reservoirs, and distribution mains are designed based on 2015 water demand.
- Gravity system should be introduced as much as possible to save energy cost.
- Groundwater should be developed to substitute water shortage during dry season.
- Achieve 24-hour water supply even during dry season.
- Achieve adequate supply pressure and sufficient water by improvement of distribution system and establishment of supply block.
- Achieve simple system which enables adequate operation and maintenance.

Design criteria for transmission and distribution pipes are the same as the previous JICA Study and are as follows:

- Pipe Flow Equation：Hazen-Williams' Equation
  C value＝120(DCIP、CI)、130(PVC)
- Maximum flow velocity：2.0m/second
- Design flow for transmission pipe：Day Maximum Demand（Day Average demand x 1.2）
- Design flow for distribution system：Hourly Maximum Demand（Day Maximum Demand x 2.0）
- Minimum pressure at distribution end：10m（Hourly Maximum Demand）
- Effective capacity of service reservoir：more than six (6) hours of Day Maximum Demand

### 2-2-1-3 Population, Service Ratio, and Served Population

Future population and served population were forecasted by the previous JICA Study as shown in **Table-2.2**

**Table-2.2 Future Population, Service Ratio, and Served Population Forecasted by the Previous JICA Study**

| | 1997 | 1998 | 1999 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| Total Population (person) | 34,235 | NA | NA | 37,083 | 41,447 | 45,425 | 49,178 | 53,240 |
| Service Ratio (%) | 73% | NA | NA | 77% | 82% | 86% | 90% | 94% |
| Served Popula-Tion (person) | 24,992 | NA | NA | 28,554 | 33,987 | 39,066 | 44,260 | 50,046 |

The latest population data of Nuwara Eliya was not available during the Basic Design Study since population census has not been conducted after the previous JICA Study. Recent served population could be calculated as around 28,200 based on number of connections and average family size. This served population in year 2000 is almost same as the one in table above.

Future population in the previous JICA Study was calculated based on the population growth rate set by the UDA（Urban Development Authority） and the growth rates are as shown in **Table -2.3**.

**Table-2.3 Population Growth Rates used in the Previous JICA Study**

| | 1997 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|
| Population Growth Rate (%/annum) | 2.7 | 2.7 | 2.25 | 1.85 | 1.6 | 1.6 |

Trend of population increase in Nuwara Eliya from the year 1881 is as shown in **Figure-2.1**. As shown in this figure, population increased drastically in the last two decades along with modernization since 1970.

**Figure-2.1**

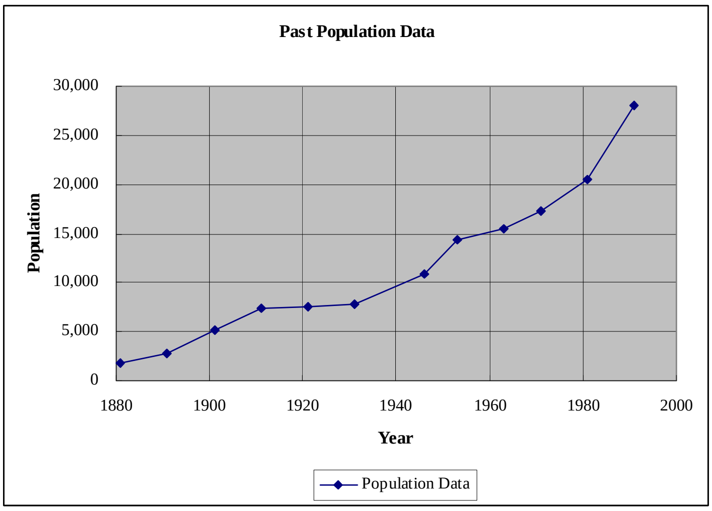
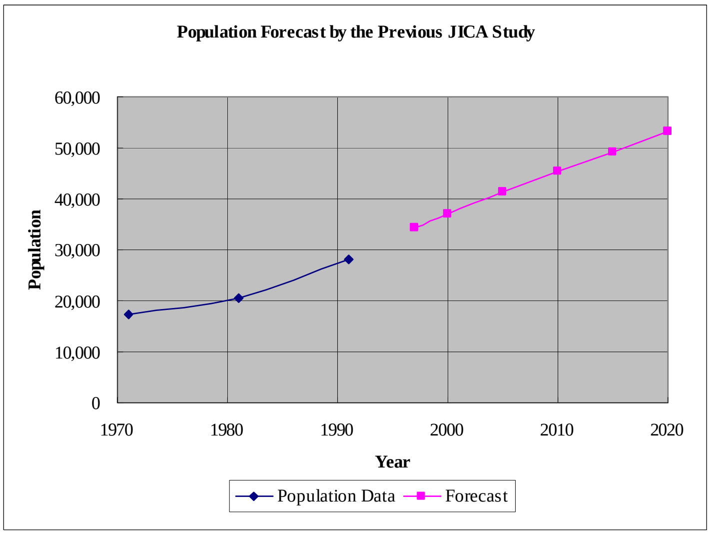



**Figure-2.2** shows the rapid population growth in the last two decades together with population forecast by the previous JICA Study. As shown on this figure, growth rate in the last two decades will continue to prevail in the near future but the rate will slightly decrease toward the year 2020 because of limitation of land space in Nuwara Eliya.

**Figure-2.2**




Although population forecast made in the previous JICA Study could not be verified since recent population data was not available, future population forecasted in the previous JICA Study was employed also in this Basic Design Study for the reasons listed below.

- The previous JICA Study was completed in February 1999 and time lag with the Basic Design Study is negligibly small.
- No big scale projects, which would affect population in Nuwara Eliya, were implemented after the previous JICA Study.
- Current served population and forecasted served population in the previous JICA Study is almost the same as mentioned above.

According to the results of the previous JICA Study, service ratio in year 2005 is estimated as 82 % and served population was 33,987 which is equivalent to about 5,300 connections and this means 1,000 connections from existing 4,335 connections. This increase will be achieved by installing one connection everyday and 200 connections annually until year 2005 and there will be no difficulties in achieving this from considering Nuwara Eliya waterworks' capacity.

Population, service ratio, served population in year 2000, 2005 and 2015 will be as shown on **Table-2.4**.

**Table-2.4 Population, Service Ratio, and Served Population in year 2000, 2005 and 2015**

| | **Year 2000（Current）** | **Year 2005** | **Year 2015** |
|---|---|---|---|
| Population | 37,083 | 41,447 | 49,178 |
| Service Ratio (%) | 77% | 82% | 90% |
| Served Population | 28,554 | 33,987 | 44,260 |

### 2-2-1-4 Per Capita Water Consumption

To calculate per capita water consumption, water distribution records in 1994, 1995, and 1997 were reviewed by the previous JICA Study and the Study employed the data in 1995 because the year 1995 had more precipitation than other years and water supply condition was better than other years. Calculation under the previous JICA Study using 1995 data is as follows.

| | | |
|---|---|---|
| Total Water Consumption in 1995 | : | 1,405,797 $m^3$/year |
| Number of Connections in 1995 | : | 3,936 connections |
| Water Consumption per connection | : | 978 l /connection/day |
| Average Family Size | : | 6.5 person |
| Per Capita Water Consumption | : | 151 lpcd |

Per capita consumption was calculated at 151 lpcd as shown above.

Under this Basic Design Study, water distribution records from 1997 to 1999 were reviewed and the per capita consumption were calculated in range of 133 to 157 lpcd as shown on **Table-2.5**. Therefore, estimated per capita consumption under the previous JICA Study, 151 lpcd, was judged to be at adequate level for planning purpose. Increase of the per capita consumption in future is not considered because the target year of the project is 2005 which is not far in the future, and also 151 lpcd is not low level figure comparing with ones of other developing countries.

**Table-2.5 Record of Water Distribution from 1997 to 1999**

| | 1997 | 1998 | 1999 |
|---|---|---|---|
| Total Water Consumption ($m^3$/year) | 1,282,736 | 1,550,969 | 1,468,786 |
| Number of Connection | 4,065 | 4,177 | 4,279 |
| Consumption per Connection (l/day/connection) | 865 | 1,017 | 940 |
| Average Family Size (person) | 6.5 | 6.5 | 6.5 |
| Per Capita Consumption (lpcd) | 133 | 157 | 145 |

Therefore, the Basic Design Study employed the figure 151 lpcd as the per capita consumption.

### 2-2-1-5 Unaccounted-for Water

The previous JICA Study estimated the Unaccounted-for water ratio as shown on **Table-2.6**.

**Table-2.6 Estimated Unaccounted-for Water Ratio by the Previous JICA Study**

| | **1997** | **2000** | **2005** | **2010** | **2015** |
|---|---|---|---|---|---|
| Unaccounted-for Water Ratio (%) | 56 | 56 | 40 | 33 | 25 |

Under this project, one route of distribution main will be replaced because the pipe has many records of leakage. However, scope of this project does not include large-scale pipe replacement to reduce the leakage. After implementation of the Project, supply block with metering system will be established and the Nuwara Eliya Waterworks will be able to evaluate unaccounted-for water in respective supply blocks. Based on the results of the evaluation, the Waterworks will be able to prioritize supply blocks which might have higher unaccounted-for water ratio and concentrate countermeasures on those block. Therefore, the target ratio of unaccounted-for water 40 % in year 2005 is judged reasonable and achievable level by repairing visible leakage on house connection, and replacement of defective meters.

### 2-2-1-6 Day Average Water Demand

Day average water demand is calculated from future served population, per capita consumption and unaccounted-for water ratio as shown on **Table-2.7**. Amount of the day average water demand is same as the previous JICA Study since same basic figures, future served population, per capita consumption and unaccounted-for water ratio, were employed.

**Table-2.7 Day Average Water Demand in 2005 and 2015**

| | Year 2005 | Year 2015 |
|---|---|---|
| Served Population | 33,987 | 44,260 |
| Per Capita Consumption (lpcd) | 151 | 151 |
| Water Demand ($m^3$/day) | 5,132 | 6,683 |
| Unaccounted-for Water Ratio (%) | 40 | 25 |
| Day Average Water Demand ($m^3$/day) | 8,506 | 8,919 |

### 2-2-1-7 Peak Factor（Day Maximum/Day Average Water Demand）

Peak factor was estimated to calculate the Day Maximum Water Demand from the above Day Average Water Demand. The peak factor is multiplied to Day Average Water Demand to absorb yearly water demand fluctuation. In this study, monthly water consumptions in the past three years, 1997 to 1999, were reviewed and the factor was calculated. **Table-2.8** shows monthly water consumption in past three years.

**Table-2.8 Average Monthly Water Consumption in Past Three Years（1997～1999）**

| Month | Average Monthly Water Consumption（$m^3$/Month） | Fluctuation（Average : 1） |
|---|---|---|
| Jan | 132,470 | 1.11 |
| Feb | 111,368 | 0.93 |
| Mar | 107,384 | 0.90 |
| Apr | 97,591 | 0.82 |
| May | 117,722 | 0.99 |
| Jun | 123,194 | 1.03 |
| Jul | 129,228 | 1.08 |
| Aug | 122,312 | 1.02 |
| Sep | 129,491 | 1.08 |
| Oct | 117,568 | 0.98 |
| Nov | 115,264 | 0.96 |
| Dec | 130,573 | 1.09 |

From the table above, maximum fluctuation of water consumption is about 1.1. This figure is almost same as figure calculated by the previous JICA Study. Although water consumption in the above figure includes water consumption by tourists, it is considered that the actual water consumption by the tourists was not accurately included because tourism season is in dry season when water shortage is the most severe. Water consumption by the tourist was estimated 10 % of the Day Average Water Demand and the peak factor was estimated 1.2, adding 10 % to 1.1, by the previous JICA Study. After the previous JICA Study, large scale tourism development, such as construction of new hotels or improvement of transportation system for tourists, have not been taken place, there is no tendency of increasing tourism water demand. Accurate number of tourists to Nuwara Eliya is not available, the ratio 10% is reasonable and peak factor 1.2 was therefore employed by the Basic Design Study.

### 2-2-1-8 Day Maximum Water Demand

Day Maximum Water Demand is calculated as shown on **Table-2.9** from the Day Average Water Demand and the peak factor mentioned above.

**Table-2.9 Day Maximum Water Demand in 2005 and 2015**

| | Year 2005 | Year 2015 |
|---|---|---|
| Day Average Water Demand ($m^3$/day) | 8,506 | 8,919 |
| Peak Factor | 1.2 | 1.2 |
| Day Maximum Water Demand ($m^3$/day) | 10,200 | 10,700 |

### 2-2-1-9 Development of New Water Source

#### (1) Required Capacity of New Water Source

In the previous JICA Study, development of new water source was planned based on year 2015 water demand since difference of water demand between year 2005 and 2015 was negligible. Under this Basic Design Study, in accordance with Japan's Grant Aid policy to cover urgently required water demand, new water source development is planned based on year 2005 water demand which is the target year of the project.

**Table-2.10 Required Capacity of New Water Source in 2005 (Phase 1)**

| Description | Quantity in Year 2005 |
|---|---|
| (a) Day Average Water Demand | 8,506 |
| (b) Day Maximum Water Demand (ａ x 1.2) | 10,200 |
| (c) Present Capacity of Water Source during Dry Season | 4,245 |
| (d) Required Capacity of New Water Source (b-c） | 5,955 |

Although required capacity in year 2005 is 5,955 $m^3$/day as shown on table above, actual capacity required should be calculated from water balance in the respective supply blocks.

**Table-2.11 Water Balance by Supply Block in Year 2005 ($m^3$/day)**

| Supply Block | Present Capacity of Water Source in Dry Season | Water Demand in Year 2005 | Required Capacity of New Water Source |
|---|---|---|---|
| High Area 1-1 | 255 | 175 | - |
| High Area 1-2 | 1,061 | 864 | - |
| High Area 1-3 | 702 | 646 | - |
| High Area 2 | 600 | 561 | - |
| Low Area 1 | 1,327 | 5,978 | -4,651 |
| Low Area 2 | 0 | 1,744 | -1,744 |
| Bonavista | 300 | 232 | - |
| Total | 4,245 | 10,200 | -6,395 |

Total required capacity of the new water source will be about 6,500 $m^3$/day in year 2005 as shown on table above.

This required capacity was calculated based on the condition that unaccounted-for water ratio would be reduced gradually from current 56 % to 40 % in year 2005. In the case that the speed of reduction is more rapid and rate is less than 40 %, required quantity of new water source can be reduced. However, existing water supply system does not have adequate measuring system and therefore the cause of high unaccounted-for water ratio can not be evaluated. Lack of measuring system and unknown reason of unaccounted-for water will not allow to prepare or implement effective unaccounted-for water reduction measures which enable such drastic. Therefore, under the Project, new water source development of 6,500 $m^3$/day will be implemented and simultaneously, improvement of measuring system and introduction of water supply block system to enable evaluation of unaccounted-for water and to prepare and implement effective countermeasures for reduction.

**(2) New Water Source**

In the previous JICA Study, new surface water source, the Jayalanka River and the Banbarakere River, and groundwater were considered as a new water sources. In case of surface water, water flow will decrease during dry season, and the Study judged that the construction of dam was indispensable to reserve raw water during rainy season. The Study pointed out that the construction of dam would require relocation of inhabitant and would cause negative environmental impacts. Development costs of each water source were compared and the cost for groundwater, about Rs. 18, was much lower than the cost of surface water, Rs. 44 to 75. Finally the Study concluded that the groundwater development as a new water source was the most feasible.

The Basic Design Study confirmed the possibility of groundwater development by geophysical inspection, test boring, and groundwater recharge analysis and prepared the design to cover water requirement by groundwater development.

Groundwater will be utilized in dry season when surface water is not sufficient. In rainy season, only surface water will be utilized.

**2-2-1-10 Water Quality**

NWSDB adopts WHO Guidelines as drinking water quality standard. Water supply system should be designed to satisfy this standard and to distribute potable water. Quality of raw water in Nuwara

Eliya is almost satisfactorily suitable as drinking water source and specific water treatment will not be required except disinfection by chlorination.

### 2-2-1-11 Water Transmission and Distribution System

Existing water supply system consists of several intakes, reservoirs, and pipelines connecting intakes and reservoirs and is rather complicated. This situation makes difficult for the Waterworks to maintain adequate quantity and pressure of the system. Under the Basic Design Study, the relation of intake – reservoir – supply block was reviewed and simplified. In some supply blocks, water source will be altered according to dry and rainy seasons. However, design was made to avoid change the relation between service reservoir and supply block. Upon completion of these system improvements, quantity of water supplied from respective service reservoir and water consumption in respective supply block will be able to be monitored continuously.

For setting up supply block boundaries, topographical condition, elevation, was taken into account to maintain constant supply pressure as much as possible and to avoid extreme pressure due to elevation. Waterworks will be able to control supply pressure more easily by introduction of this supply block concept.

Capacity of each service reservoir, which is distribution center of the respective supply block, were decided from water demand. Four (4) new reservoirs will be constructed and two (2) existing reservoirs will be expanded. Stable and continuous water supply throughout 24 hours will be achieved by this improvement of service reservoirs.

While some trunk mains were planned to be used as transmission and distribution functions simultaneously in the previous JICA Study, pipelines were designed to be clearly distinguished by their role under the Basic Design Study.

Gravity system should be introduced as much as possible in transmission and distribution system. In exceptional cases to supply water to remote area or high elevation area, booster pumping will be employed. Booster pumping should be direct pumping to effectively use residual pressure.

#### 2-2-1-12 Procurement of Water Meters and Meter Test Bench

At present, there are approximately 800 defective water meters, about 18 % of water meters, in Nuwara Eliya and new 800 water meters will be supplied for replacement under this Project. Meters will be procured in Sri Lanka which are usually used by waterworks. Supply of meter test bench for calibration of water meter will also be included in the scope of project. By improvement of the metering system, the Waterworks will have accurate data of water consumption and it will contribute to unaccounted-for water reduction. Waterworks of Nuwara Eliya shall carry out the work for replacement of water meters. Meter calibration using the meter test bench will require training. Staff of Nuwara Eliya Waterworks can be trained with NWSDB in Colombo Waterworks which has the meter test bench.

### 2-2-2 Basic Plan

#### 2-2-2-1 Overall Plan

Overall system plan is shown on **Figure-2.3** and schematic systems in dry and rainy seasons are shown on **Figures-2.4** and **2.5** respectively. **Table-2.12** shows the results of the Basic Design to the original scope of the project requested by GOSL.

Major scope of the project derived from the Basic Design Study based on design concepts described in the previous section is as follows:

1. Development of groundwater source to substitute water shortage in dry season by constructing new wells. Quantity of abstraction will be 4,000 $m^3$/day in Hawa Eliya (@800 $m^3$/day x 5 wells) and 3,200 $m^3$/day in Golf Course (@800 $m^3$/day x 4 wells)
2. Establishment of supply block which enables quantity and pressure control. Boundary valves will be installed on supply block boundaries (25 locations, dia 50 mm～225 mm)
3. Installation of transmission pipelines (L = 10.0 km, dia. 75 mm～300 mm)and distribution pipelines (L = 7.2 km, dia. 75 mm～250 mm) to distinguish transmission and distribution system and to establish the supply block. Installation of groundwater transmission pipelines, L = 7.1 km, dia. 160 mm～250 mm.
4. Construction of 6 service reservoirs for 24-hour continuous and stable water supply. Each reservoir will be equipped with chlorination and metering facilities.

| Service Reservoir | Capacity ($m^3$) | Remarks |
|---|---|---|
| Old Water Field | 110 | New |
| Pedro | 130 | New |
| Unique View | 190 | Expansion |
| Vijithapura | 110 | Expansion |
| Low Area 2 | 460 | New |
| Gemunupura | 40 | New |

5. Provision of 800 water meters for replacement of existing defective meters together with a meter test bench for water meter calibration.

As shown on **Table-2.12**, scopes after the Basic Design differ from the original scope requested by GOSL. Reasons of these alterations are as follows:

- Location of groundwater development and number of wells are revised based on the results of geophysical investigation and test boring.
- Mayor of Nuwara Eliya Municipality strongly requested to include Gemunupura area into service area, where excluded from service area in the previous JICA Study. As a result of field investigation and analysis, Gemunupura area, which had about 50 households, was decided to be included into service area by constructing small distribution reservoir. Because of additional small reservoir, planned capacity of Vijithapura reservoir could be reduced.
- Route, diameter, and length of transmission pipelines were altered because of shifting well location and inclusion of Gemunupura as service area, to distinguish transmission and distribution system, and for easier operation and maintenance. Booster pumping station plan is also altered accordingly.
- Route, diameter, and length of distribution pipelines were altered because of rearrangement of supply block and inclusion of Gemunupura as service area, to distinguish transmission and distribution system, and for easier operation and maintenance.
- Capacities of service reservoir were revised because of rearrangement of supply block and to distinguish transmission and distribution system. Service reservoir at Gemunupura was newly added because of inclusion of Gemunupura as service area.
- Location, number, and diameter of bulk water meter were altered based on revision of distribution quantity.

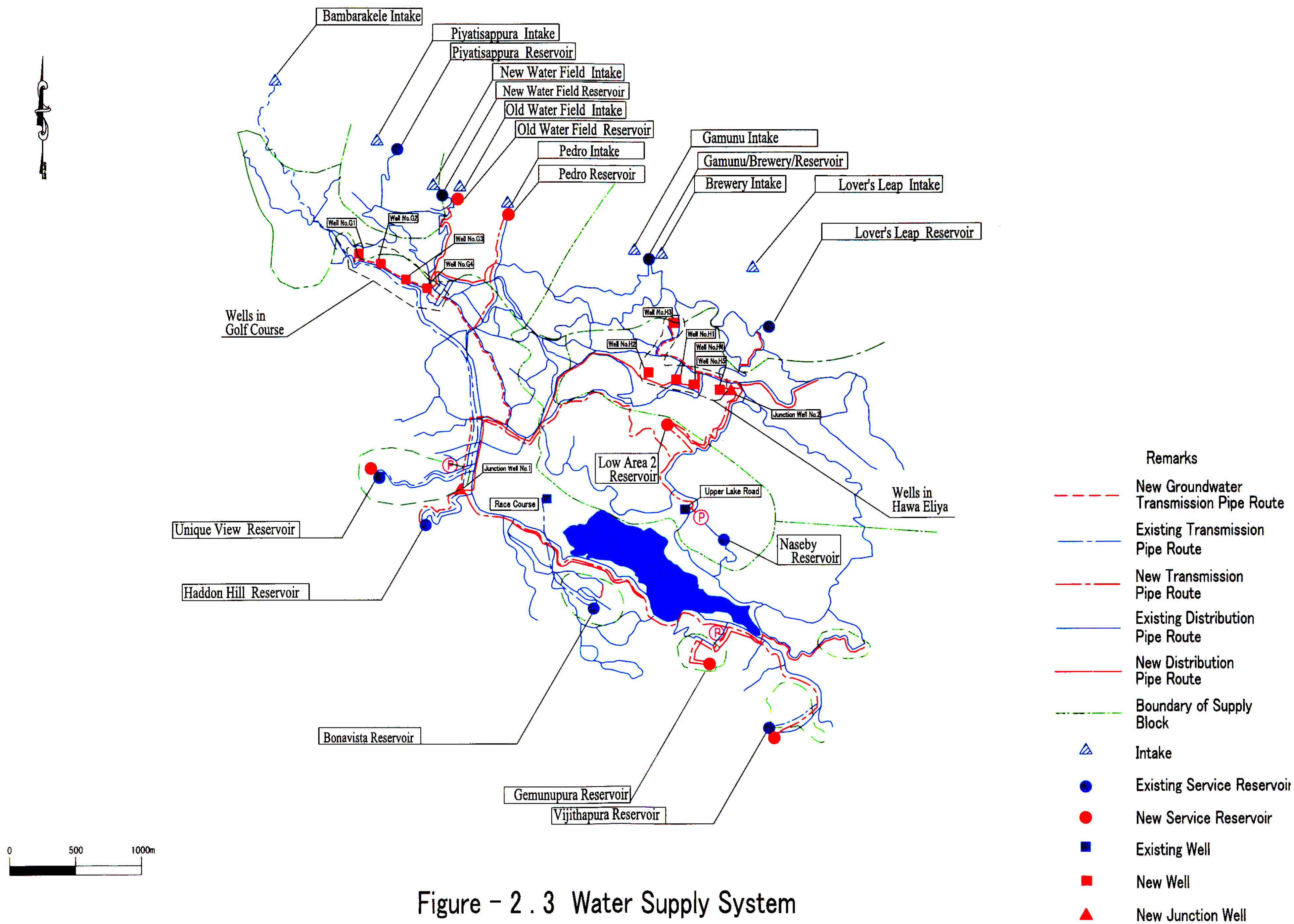
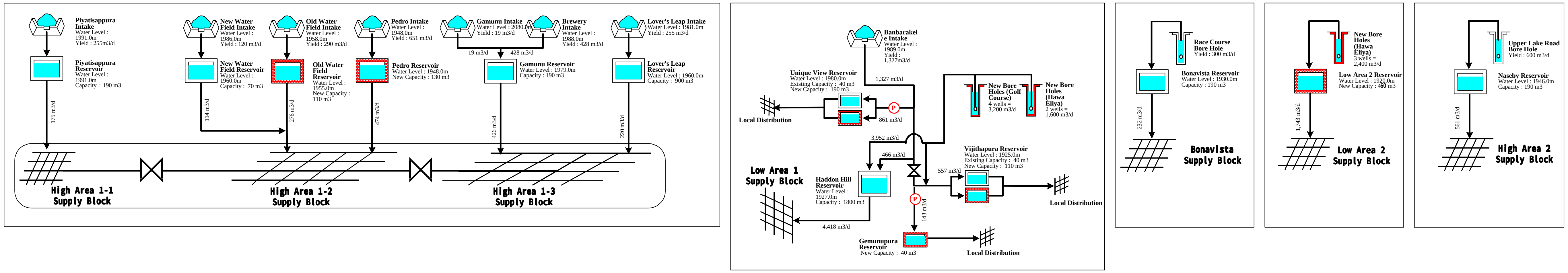
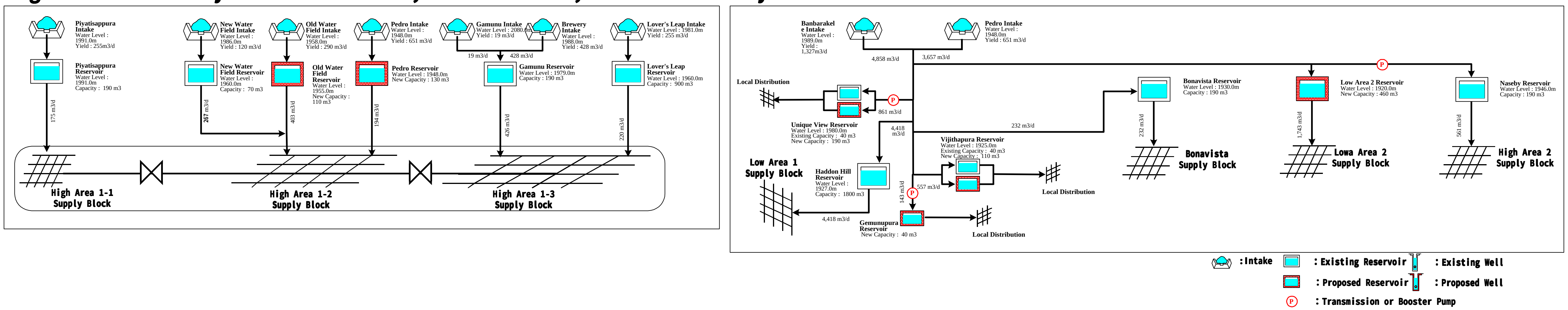



Figure - 2 . 3 Water Supply System

## Figure-2.4 Dry Season : Intake, Transmission, Distribution System




## Figure-2.5 Rainy Season : Intake, Transmission, Distribution System



## Table-2.12 Scope Originally Requested by GOSL and Results of the Basic Design Study

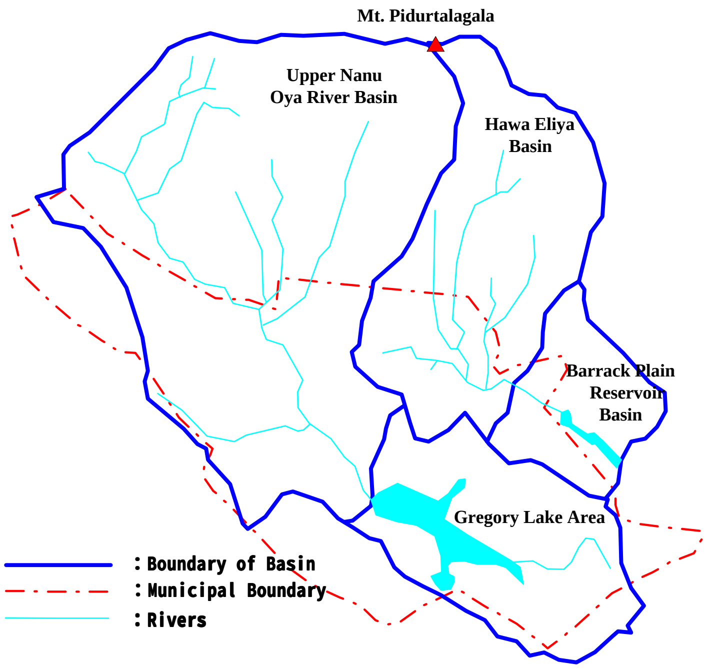
| Facility | Item | Specifications | Unit | Quantity | |
|---|---|---|---|---|---|
| | | | | Original | Revised |
| Wells and | Wells | For Low Area 1 (Race Course System) | location | 150m x 5 | |
| | | Golf Course 4 wells | location | - | 100m x 4 |
| | | Hawa Eliya 2 wells | location | | 100m x 1 |
| | | | | | 60m x 1 |
| | | For Low Area 2 (Hawa Eliya System) | location | 150m x 2 | 100m x 1 |
| | | Hawa Eliya 3 wells | location | - | 80m x 1 |
| | | | location | - | 60m x 1 |
| | Well Pumps | For Low Area 1 (Race Course System) | unit | 1,000m$^3$/dx 58m x 5 | 800m$^3$/d x 55m x 1 |
| | | Hawa Eliya 2 wells | unit | - | 800m$^3$/d x 50m x 1 |
| | | Golf Course 4 wells | unit | - | 800m$^3$/d x 30m x 4 |
| | | For Low Area 2 (Hawa Eliya System) Hawa Eliya 3 wells | unit | 1,000m$^3$/dx 58m x 2 | 800m$^3$/d x 30m x 3 |
| | Electrical System | | set | 7 | 6 |
| | Pump House | | location | 10m$^2$ x 7 | 10m$^2$ x 6 |
| Groundwater Transmission | Pipes | DCIP φ 250 mm | m | - | 2,299 |
| | | PVC φ 225 mm | m | - | 3,134 |
| | | PVC φ 160 mm | m | 1,240 | 1,688 |
| | | Total | m | 1,240 | 7,121 |
| | Junction Well | | m$^3$ | - | 30 m$^3$ x 2 |
| | Junction Well Pump | To Haddon Hill | - | 5,000 m$^3$/d x 68 m | 3,925 m$^3$/d x 60 m |
| | | To Gemunupura/Vijithapura | - | - | 700 m$^3$/d x 75 m |
| | | To Low Area 2 | - | 1,900 m$^3$/d x 63 m | 1,743 m$^3$/d x 80 m |
| | Electrical System | | set | 2 | 2 |
| | Pump House | For Low Area 1 (Race Course) | location | 25m$^2$ x 1 | 36 m$^2$ x 1 |
| | | For Low Area 2 (Hawa Eliya) | location | 25m$^2$ x 1 | 60 m$^2$ x 1 |
| Transmission | Pipes | DCIP φ 300 mm | m | 4,320 | 983 |
| | | DCIP φ 250 mm | m | 3,545 | 2,175 |
| | | PVC φ 225 mm | m | 700 | 4,252 |
| | | PVC φ 160 mm | m | - | 1,115 |
| | | PVC φ 110 mm | m | 2,867 | 963 |
| | | PVC φ 75 mm | m | - | 468 |
| | | Total | m | 11,432 | 9,956 |
| | Pumps | Naseby | - | 600 m$^3$/d x 25m | 561 m$^3$/d x 25 m |
| | | Vijithapura | - | 690 m$^3$/d x 25m | - |
| | | Unique View | - | 920 m$^3$/d x 85m | 861 m$^3$/d x 75 m |
| | | Gemunupura | - | - | 143 m$^3$/d x 25 m |
| | Pump House | | location | 4m$^2$ x 3 | 13 m$^2$ x 2 |
| | Electrical System | | set | 3 | 2 |
| Distribution | Reservoirs | Old water field | m$^3$ | 100 | 110 |
| | | Pedro | m$^3$ | 220 | 130 |
| | | Unique View | m$^3$ | 200 | 190 |
| | | Vijithapura | m$^3$ | 140 | 110 |
| | | Low area 2 | m$^3$ | 470 | 460 |
| | | Gemunupura | m$^3$ | - | 40 |
| | | Total | m$^3$ | 1,130 | 1,040 |
| | Chlorinator | | set | 3 | 6 |
| | Chlorinator House | | location | 10m$^2$ x 3 | 12m$^3$ x 6 |
| | Flow Meter | | location | 10 (dia300-75) | 9 (dia250-50) |
| | Pipes | DCIP φ 300 mm | m | 2,069 | - |
| | | DCIP φ 250 mm | m | - | 939 |
| | | DCIP φ 100 mm | m | - | 100 |
| | | PVC φ 225 mm | m | 1,760 | 455 |
| | | PVC φ 160 mm | m | 1,828 | 1,686 |
| | | PVC φ 110 mm | m | 1,839 | 1,396 |
| | | PVC φ 75 mm | m | 1,460 | 2,600 |
| | | Total | m | 8,956 | 7,176 |
| Others | Boundary Valves | φ 50mm～φ 225mm | location | - | 25 |
| | Water Meter | for replacement of defective meters | pcs. | - | 800 |
| | Meter Test Bench | for meter calibration | set | - | 1 |
| | Valve Repair | φ 100mm～φ 300mm | location | - | 11 |

### 2-2-2-2 Facility Plan

### (1) Development of Groundwater Source

### 1) Natural Conditions

The Study area located in the central mountain ranges of Sri Lanka, spreads in a basin with an area about seven km from east to west and six km from north to south. The geology of the Study area is mainly consists of metamorphic rocks of Pre-Cambrian in age such as gneiss, which forms a major anticlinal fold structure with the axis of NW-SE direction associated with series of minor folds. Two major shear faults are running almost in parallel with the axis of the major fold, developing deep valleys. The southwestern valley is called the Upper Nanu Oya river basin (15.71 $km^2$ in area, including Gregory Lake) and the northeastern valley is called the Barrack Plain Reservoir basin (7.19 $km^2$ in area, including Hawa Eliya with an area of 5.51 $km^2$). In this Study, the Upper Nanu Oya river basin is divided into two areas. Consequently, the Gregory Lake area (3.48 $km^2$ in area) is discriminated independently from anew-called Upper Nanu Oya area (12.23 $km^2$ in area). The change in storage (dS/dt) is considered in the model, but not listed in the tables as the values are minor. These basins are shown on figure below.



Annually averaged precipitation for 5 years from 1995 through 2000 at the Upper Nanu Oya river basin is 2,247.2 mm, and 2,050.9 mm at Hawa Eliya. Evapotranspiration from wide spread forest and tea field is estimated as 584.3 mm and 600.9 mm, respectively. Annually averaged run off is also estimated as 1,112.1 mm and 1,014.4 mm, respectively. Based on these data, groundwater recharges are estimated to be 17,300 $m^3$/day in the Upper Nanu Oya river basin and 8,520 $m^3$/day in Hawa Eliya. These water balances, precipitation, evapotranspiration, effluent, and groundwater recharge in Nanu Oya river basin and Hawa Eliya are shown on **Table 2.13** and **Table 2.14**, respectively. The change in storage (dS/dt) is considered in the model, but not listed in the tables as the values are minor.

**Table-2.13 Water Balance in Nanu Oya River Basin**

| Year | Precipitation (mm) | Evapotranspiration (mm) | Effluent (mm) | Groundwater Recharge (mm) |
|---|---|---|---|---|
| 1995/96 | 2290.8 | 619.7 | 1033.4 | 473.2 |
| 1996/97 | 1871.3 | 560.3 | 881.6 | 426.5 |
| 1997/98 | 2540.3 | 563.7 | 1379.3 | 625.6 |
| 1998/99 | 2095.8 | 570.8 | 1060.1 | 506.9 |
| 1999/00 | 2437.9 | 607.1 | 1206.1 | 560.9 |
| Average | 2247.2 | 584.3 | 1112.1 | 518.6 |

**Table-2.14 Water Balance in Hawa Eliya Basin**

| Year | Precipitation (mm) | Evapotranspiration (mm) | Effluent (mm) | Groundwater Recharge (mm) |
|---|---|---|---|---|
| 1995/96 | 2090.6 | 640.9 | 968.7 | 432.4 |
| 1996/97 | 1707.8 | 575.4 | 792.2 | 336.3 |
| 1997/98 | 2318.3 | 572.1 | 1256.6 | 519.6 |
| 1998/99 | 1912.7 | 589.3 | 951.6 | 393.3 |
| 1999/00 | 2224.9 | 627.0 | 1102.8 | 480.9 |
| Average | 2050.9 | 600.9 | 1014.4 | 432.5 |

### 2) Existing Condition of Groundwater

There are six deep wells are being used now; among them two wells at Upper Nanu Oya area, threee wells at Gregory lake area and one well at Barrack Plain Reservoir basin. There are three shallow wells; one at Race Course area, one at Gregory lake area and the other at Barrack Plain Reservoir area.

Among these nine wells, two are operated and maintained by Nuwara Eliya Waterworks, and others are used by private sector. Each well depth varies from 15 m to 93 m, which understand that the quality and depth of an aquifer change with geological conditions of the place. Groundwater from these wells of private sector is used for substitution of municipal water supply in dry season. The Upper Lake Borehole of the Waterworks is an artesian well, which is used only in the dry season.

Although the shallow wells are mainly used as domestic miscellaneous uses, it is used for washing of bottles at the beer factory, and the other is used for irrigation in the dry season. **Table-2.15** shows the list of these wells.

**Table-2.15 List of wells under operation**

| Well Name／Owner | River basin／Area | Type | Depth (m) | Capacity ( $m^3$ /day) | Pumped ( $m^3$ /day) |
|---|---|---|---|---|---|
| Race Course Borehole/ Municipal Council | Upper Nanu Oya River / Race Course | Deep | 15 | >730 | 300 |
| Bank of Ceylon | Upper Nanu Oya River / Town Area | Deep | 80 | 1,440 | 5 |
| Hill Club | Upper Nanu Oya River / Town Area | Deep | 43 | 360 | 5 |
| Upper Lake Borehole/ Municipal Council | Gregory Lake Area / Upper Lake | Deep | 30 | Artesian 39 | 600 Dry season |
| Bibile Garment | Gregory Lake Area / Magastota | Deep | 93 | 346 | 90 |
| Ceylon Electric Board | Gregory Lake Area / Magastota | Deep | 33.5 | 288 | 10 |
| INCO | Barrack Plain Reservoir Area / Hawa Eliya | Deep | 36.6 | 360 | 173 Dry season |
| Mr.Karunaratne | Gregory Lake Aera / Magastota | Shallow | 1.8 | N/A | 65 Dry season |
| The Ceylon Brewery Ltd. | Barrack Plain Reservoir Area / Hawa Eliya | Shallow | 9.8 | 180 | 162 Dry season |

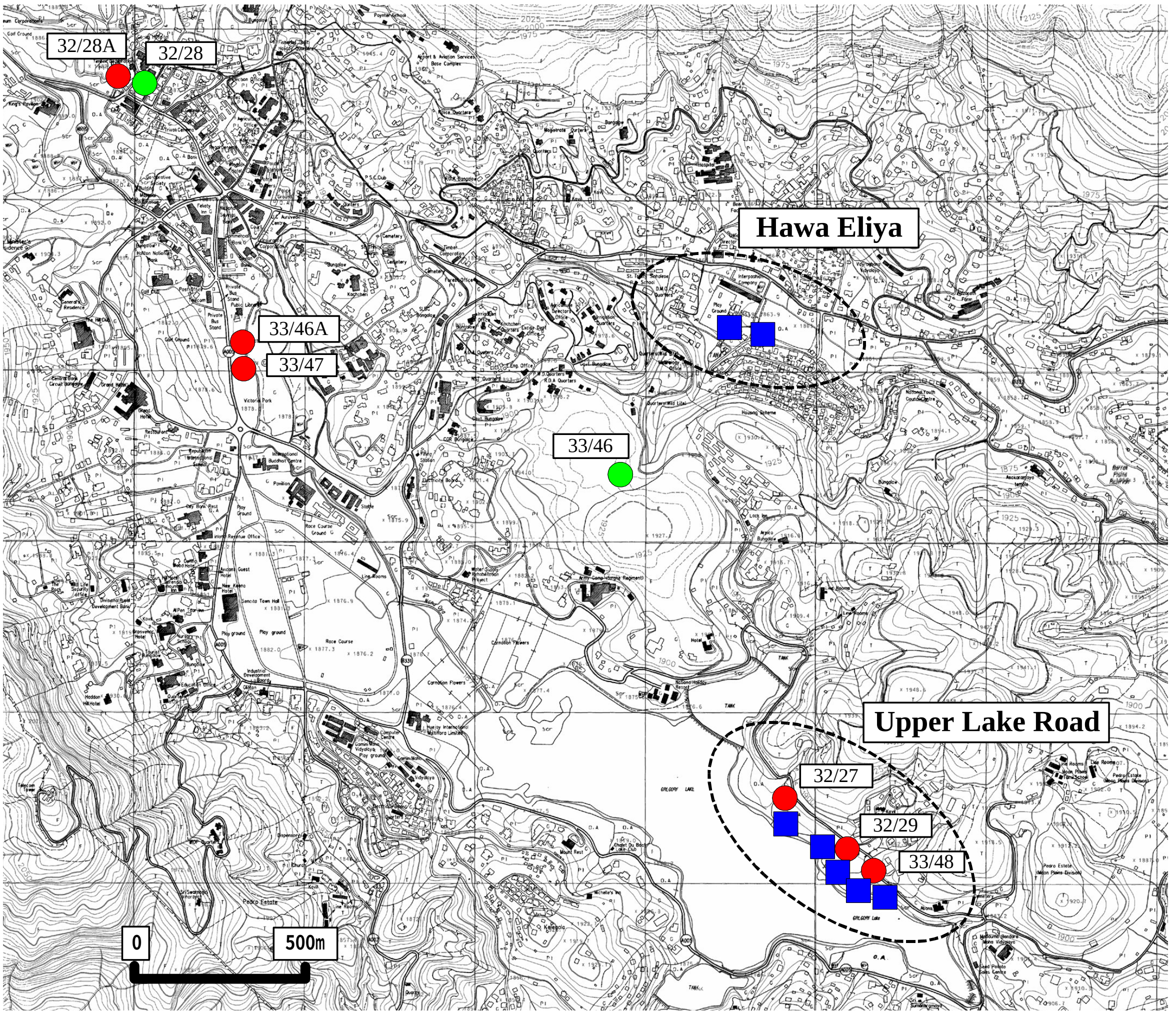
### 3) Review of the Results of the Previous JICA Study

In the previous JICA Study, eight test wells were excavated in four areas of Upper Lake Road, Galway Wildlife Bungalow, Golf Course, and Victoria Park as shown in a **Table-2.16** and **Figure-2.6**. One well (32/28A) excavated at Golf Course was obliged to discontinuation of digging for inside collapse, and two wells (33 / 47 and 33/46A) excavated at Victoria Park were interrupted similarly. Since the construction works of two wells (32/27, 33/48) at Upper Lake Road were poor, pumping tests were not carried out completely. Moreover, since groundwater level at the well (32/29) at Upper Lake Road showed unusual descent during a pumping test, the test was interrupted. The pumping tests were carried at only two wells (33/46 of Galway Wildlife Bungalow and 32/28 of

Golf Course) among eight after all.

By these pumping tests, results are obtained at both wells of 33/46 at Galway Wildlife Bungalow and 32/28 at Golf Course, showing estimated critical yield of 700 $m^3$/day and 1,100 $m^3$/day, respectively. On the other hand, for the test well 32/29 at Upper Lake Road, where the pumping test was interrupted, safety yield of groundwater was estimated as 400 $m^3$/day.

**Figure-2.6 Location of Test Wells and Proposed Location of Well Construction by the Previous JICA Study**




● Test Well constructed during the previous JICA Study, Pumping Test was failed
● Test Well constructed during the previous JICA Study, Pumping Test was succeeded
[33/46] Test Well Number
■ Proposed site of Well construction by the previous JICA Study

**Table-2.16 Test Well constructed during the Previous JICA Study**

| Test Well Number ／Site Name | Location ／Watershed | Lithology of the Aquifer | Construction Status | Dia. of Well (mm) | Drilling Depth (m) | Pumping Test Status | Critical yield ($m^3$/day) | Trans-missivity ($m^2$/day) | Safe Yield ($m^3$/day) |
|---|---|---|---|---|---|---|---|---|---|
| ３２／２７ Upper Lake Rd. 1 | Upper Lake ／Lake Gregory | Weathered Fractured Gneiss | Completed | ２２５ | 75.0 | Failed | — | — | — |
| ３２／２９ Upper Lake Rd. 2 | Ditto | ditto | ditto | ２２５ | 75.0 | Incomplete* | — | 24.8 | 400 |
| ３３／４８ Upper Lake Rd. 3 | Ditto | ditto | ditto | ２２５ | 68.0 | Failed | — | — | — |
| ３３／４６ Galway Wildlife Bungalow | Hawa Eliya ／Boburella River | Fractured Gneiss | ditto | ２２５ | 76.8 | Completed | 700 | 41.7 | 276 |
| ３２／２８A Golf Course 1 | Town Area ／Upper Reach of Nanu Oya | ditto | Suspended | ２２５ | — | — | — | — | — |
| ３２／２８ Golf Course 2 | ditto | ditto | Completed | ２２５ | 88.0 | Completed | 1,100 | 266 | 770 |
| ３３／４６A Victoria Park 1 | ditto | Weathered Fractured Gneiss | Dry Well | ２２５ | 62.0 | — | — | — | — |
| ３３／４６ Victoria Park 2 | ditto | ditto | ditto | ２２５ | 87.5 | — | — | — | — |

Note ＊： Pumping test was terminated at the rate of Q=575 $m^3$/day because of unusual draw down
Safety yield were from the results of the previous JICA Study

Although the pumping tests were successfully carried out at the above mentioned two sites (Golf Course and Galway Wildlife Bungalow) by the previous JICA Study, the areas proposed by the Study were not the place where this pumping test was successful, but Hawa Eliya, and Upper Lake Road as shown on **Figure-2.6**. The development plan for each area was as follows.

Hawa Eliya

@1,000 $m^3$/day / well × 2 wells = 2,000 $m^3$/day pumped up

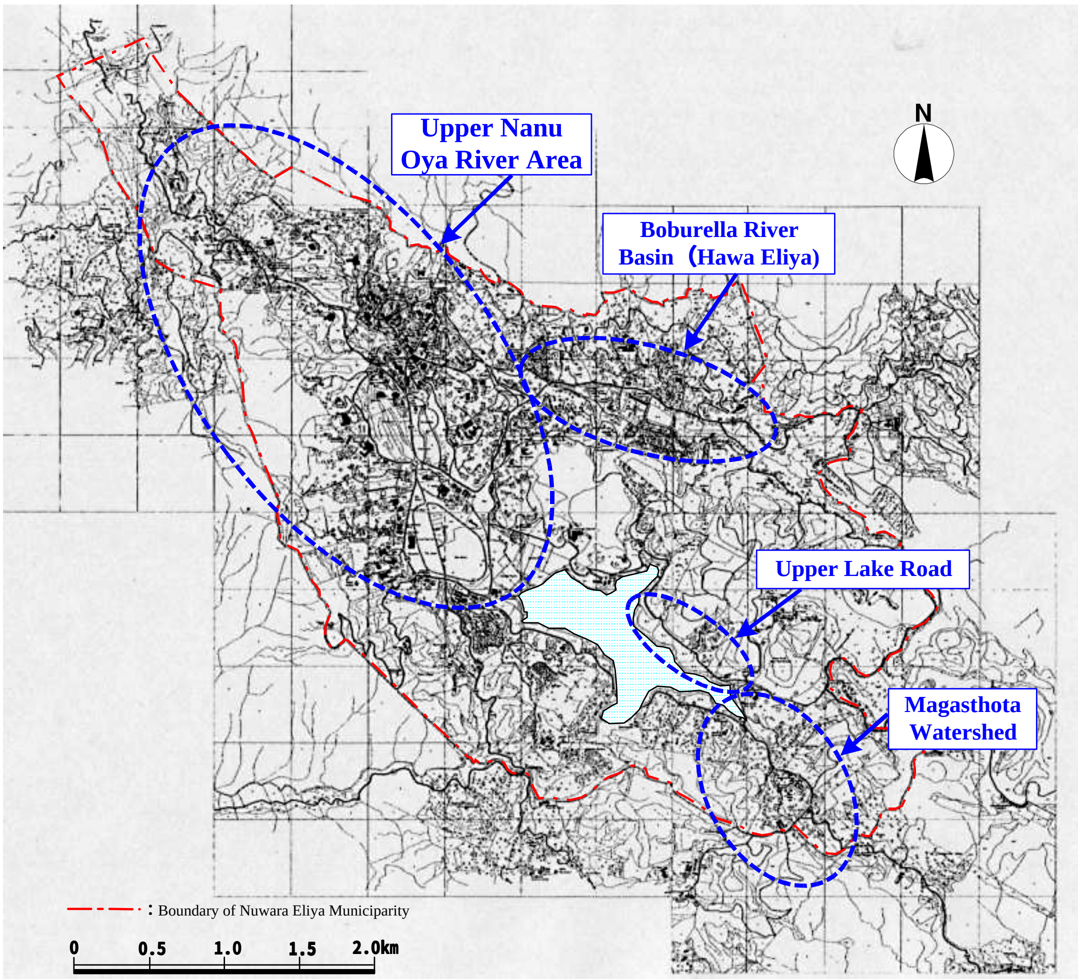
Upper Lake Road

@1,000 $m^3$/day / well × 5 wells = 5,000 $m^3$/day pumped up.

**4) Proposed Groundwater Development Sites**

Potential area of groundwater development excluding mountainous areas in Nuwara Eliya will be four areas as shown on **Figure-2.7**.

**Figure-2.7 Potential Area of Groundwater Development in Nuwara Eliya**



The Basic Design Study carried out geophysical survey (electric sounding and electromagnetic survey) over a very wide area including the groundwater development area (Hawa Eliya and Upper Lake Road) proposed by the previous JICA Study in order to understand the groundwater situation and related geological structure. As a result of the survey, some knowledge such as the depth of a basement of the weathered gneiss as shown in **Figure-2.8**, and the thickness of weathered rocks as shown in **Figure-2.9**, which were important to recognize a distribution of a groundwater aquifer, was acquired. Results of analysis on possibility of groundwater in these four areas based of the results of geophysical survey and groundwater recharge analysis are described below.

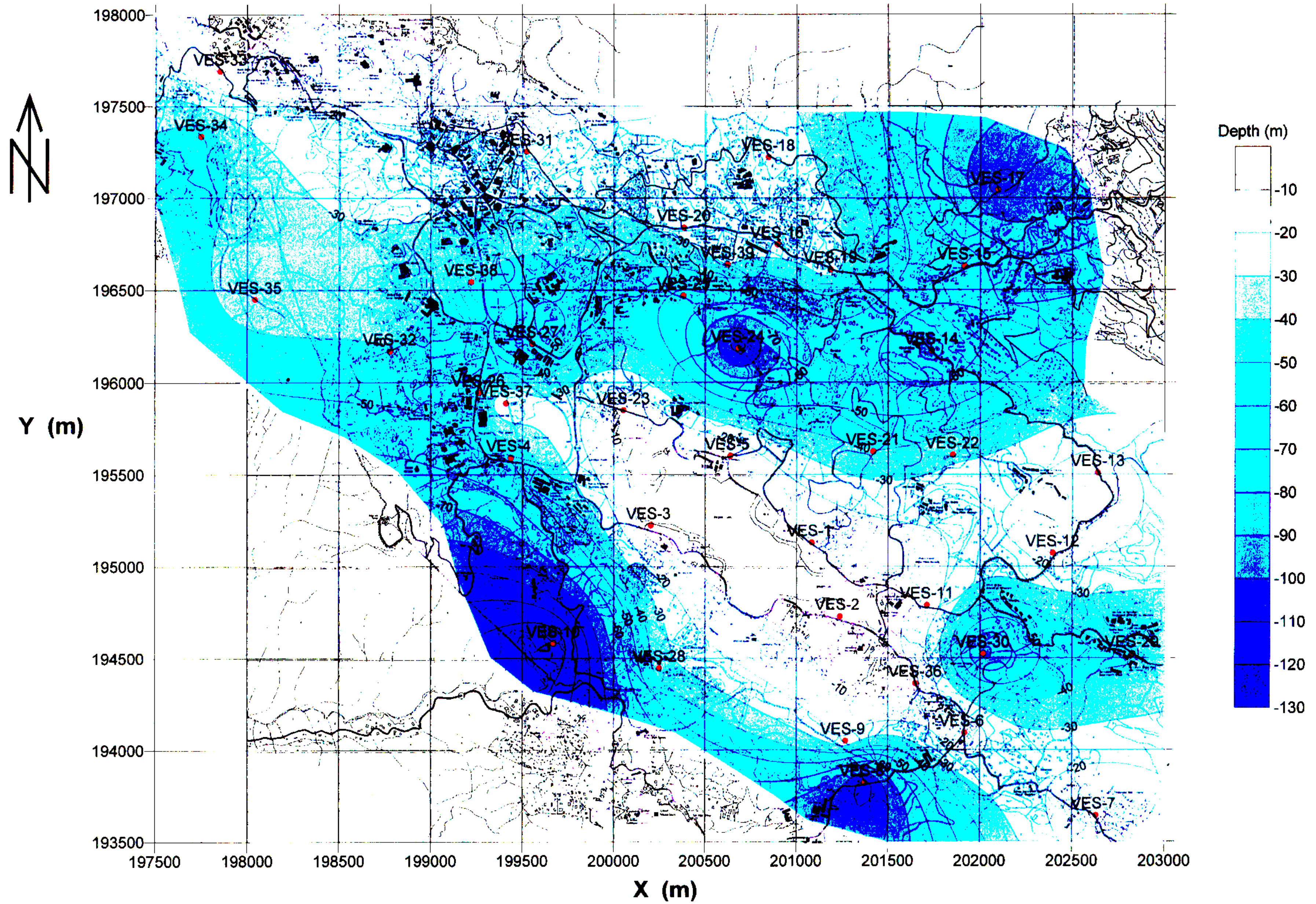



Figure-2.8 Estimated Depth of Weathered Rock Basement

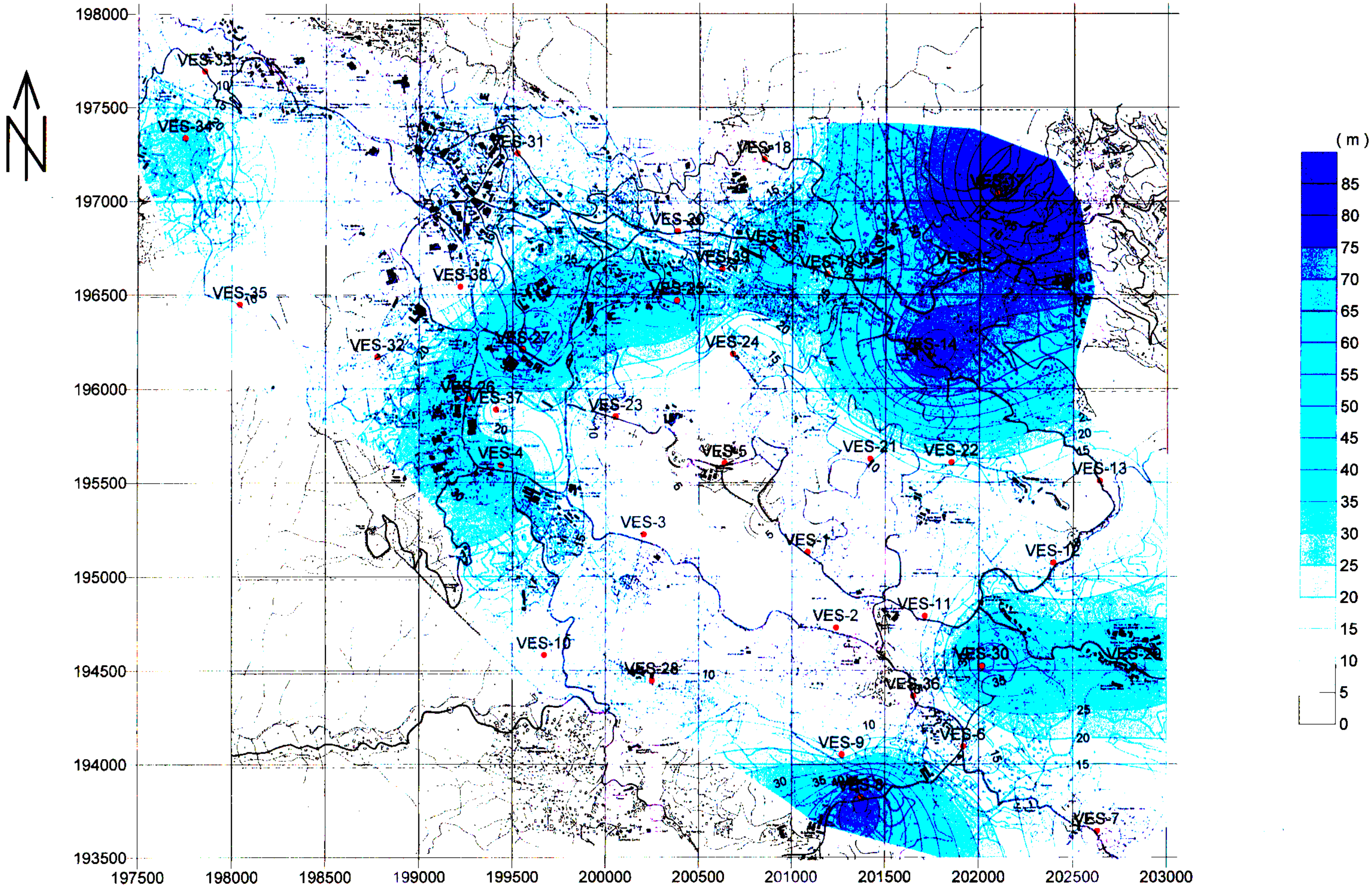



**Figure-2.9 Estimated Thickness of Weathered Rock**

**1) Upper Lake Road Area**

As for the plan proposed by the previous JICA Study in Gregory Lake area including Upper Lake Road, the geophysical Survey showed negative result that the thickness of aquifer is very thin (5 - 10 or less m) in this area.

Upper Lake Road area is located at a flat land along the northeastern bank of Gregory Lake. It lies between Gregory Lake and Upper Lake Hills, and is very small in area. Although a Major fault is running across this area, aquifer zone is weathered and its permeability is low. As the groundwater recharge is small, the groundwater development in this area may involve some risk to draw the water from Gregory Lake into this area.

The reason why the previous JICA Study proposed Upper Lake Road was mainly because that momentary water yield of more than 1,440 $m^3$/day was observed by the pumping test, although it did not succeed. As a consequent, the potential water yield of more than 1,000 $m^3$/day was estimated. However, that the momentary yield stated here does not show a maintainable safety-pumping rate. In fact, as the groundwater draw down at the first stage of the pumping test (pumping rate 575 $m^3$/day) became remarkably large, the pumping test was obliged to be interrupted. Consequently, the amount of safety pumping was estimated to be 400 $m^3$/day from this pumping test result. The conclusion of the previous JICA Study was that the results were provisional and presupposing about the groundwater development area and these provisional conclusion should be revised and corrected by the adequate pumping tests at the additional test wells constructed by suitable method.

**2) Magasthota Watershed**

The area of this watershed is small and estimated at about 0.6 $km^2$ at the mouth of a stream flowing into Gregory Lake. A major fault is running along the valley of watershed. Aquifer is formed in fractured zone developed along the fault. As the aquifer is of low permeability due to weathering, water yield at this area seems to be small.

**3) Upper Nanu Oya River Area**

The annual mean of groundwater recharge is estimated 17,300 $m^3$ /day. Groundwater basin ranges from the northwest margin of the Golf Course to the northwestern bank of Gregory Lake. Groundwater is reserved in weathered rocks of gneiss origin, located at about 20 to 50m in depth, and in fractures developed in fresh rocks of gneiss and quartzite, underlying the weathered rock. In both case, groundwater is confined. This results were also confirmed from the data obtained during the previous JICA Study. It was presumed that a thick aquifers (30m or more) exist in areas such as Haddon Hill, western side, and northern side of Race Course.

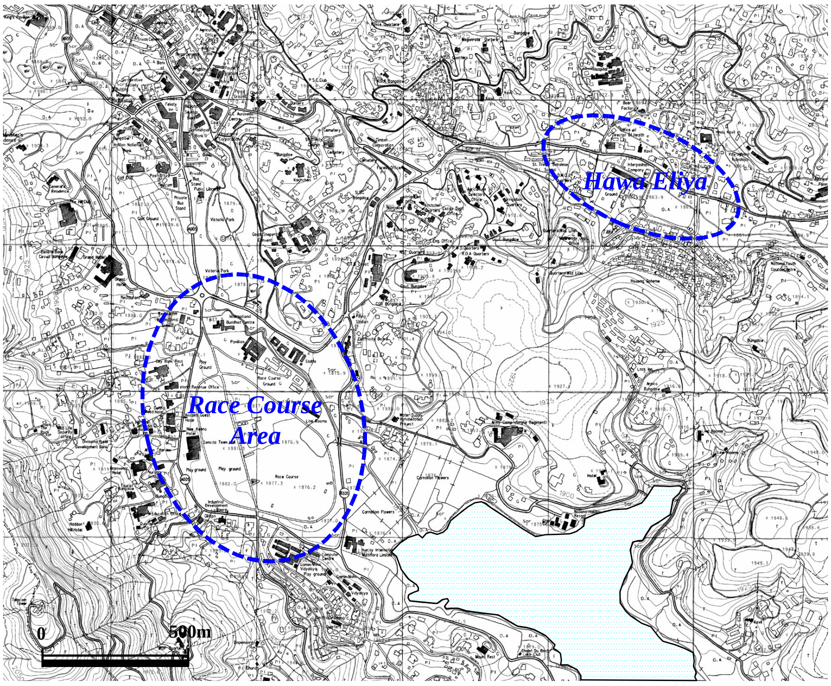
**4) Boburella River Basin (Hawa Eliya)**

Annual mean of groundwater recharge is estimated to be 8,520 $m^3$ /day. Boburella basin is surrounded in the northeastern margin by a high mountain range, which is the water source of Lover's Leap, and by Upper Lake Hills in the southwestern margin. Groundwater rising from these mountains and hills, percolated down into the weathered rock of gneiss along the slope, recharges aquifer at the bottom of the basin. Groundwater is mainly reserved in two aquifers. The shallow one consists of weathered gneiss, lying under the ground surface at about 20 to 50m in depth, and the deeper one consists of fractured rocks of gneiss and quartzite, underlying the first aquifer as same as in the Nanu Oya Upstream basin. Both aquifers are confined. It was presumed that a thick aquifers (30m or more) exist in areas such as Hawa Eliya, and Barrack Plain Reservoir area. This result supports the groundwater development plan in Hawa Eliya proposed by the previous JICA Study.

As mentioned above, the propriety of the groundwater development in Upper Lake Road area and Magasthota Watershed for this project was neither supported by the result of pumping test during the previous JICA Study nor supported by the results of geophysical investigation of the Basic Design Study.

Therefore, the Basic Design Study judged that fully securing the amount of water needed in this plan is probably difficult in Upper Lake Road and Magasthota Watershed, and these two areas should be excluded from the proposed sites. The Basic Design selected the Upper Nanu Oya River area and Boburella River Basin (Hawa Eliya) as proposed groundwater development area. Among Upper Nanu Oya River area, Race Course area was selected because of existence of thick aquifer and shorter groundwater transmission pipeline.

As described above, following two areas were selected as a more promising groundwater development proposed sites from the result of geophysical survey carried out by this Basic Design Study, the geographical feature and the geological situation of a sites.




A. Hawa Eliya area

B. Race Course area

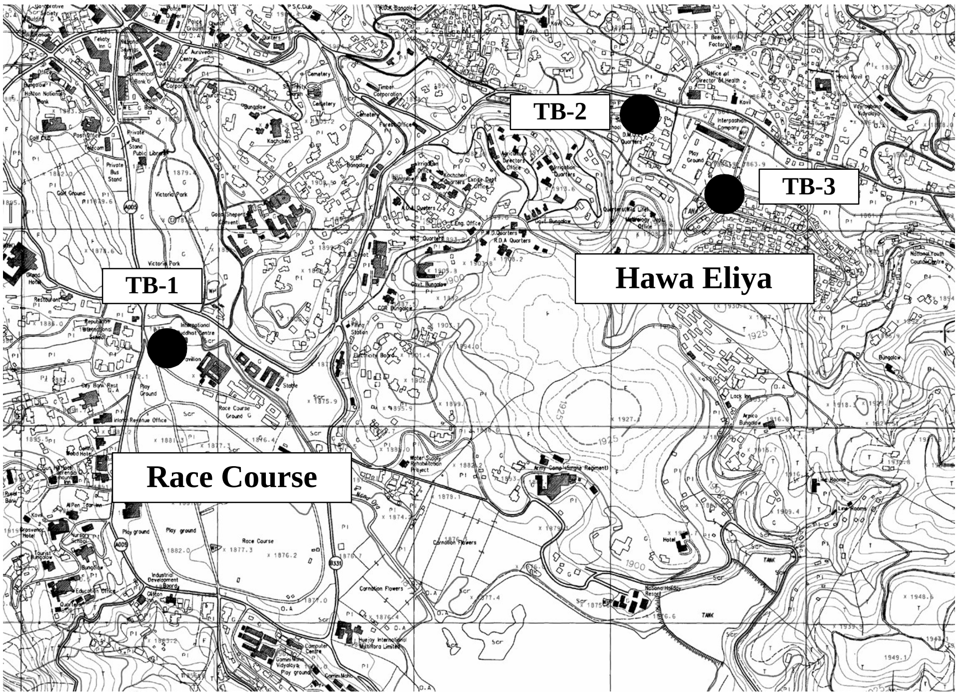
Other than the above two proposed area, the Golf Course has also high potential of groundwater development, which were confirmed by the previous JICA Study. However it was pointed out by the local government and agencies concerned that the land acquisition in the Golf Course to construct wells would be quite difficult and therefore, the Golf Course was excluded from the proposed area.

During the Basic Design study, to confirm geological features and aquifers, test borings were conducted at the above two locations, Hawa Eliya and Race Course.

## 5) Test borings for Geological Survey and Groundwater Yield Estimation

Test borings for geological survey were carried out at three sites; one in Race Course area (site name : TB-1, Race Course entrance) and two sites in Hawa Eliya area (site name : TB-2 at school front, and TB-3 at Play Ground). Location of these test borings are shown on **Figure-2.10)**

**Figure-2.10 Location map of the test borings for geological survey**




Based on the data obtained by the various investigation and the data of the existing wells, the test borings were carried out under presupposition that the groundwater aquifer in Nuwara Eliya area were characterized by shallow unconfined aquifer near surface of the earth (depth of less than 10m), and confined aquifer at the bottom of the weathered gneiss.

The result of the pumping test in each test boring is shown in a **Table-2.17**.

**Table-2.17 Result of the pumping test at the test borings**

| Test Boring | Basin/Location | Geological Condition | Depth of Boring (m) | Thickness of Aquifer (m) | Critical yield ($m^3$/day) | Trans-missivity ($m^2$/day) | Safe Yield ($m^3$/day) |
|---|---|---|---|---|---|---|---|
| TB-1 | Nanu Oya River Basin / Race Course | Gneiss, Fracture zone | 104.25 | 10.5 | 300 | 1.26 | 0.12 |
| TB-2 | Barrack Plain Reservoir Basin / Hawa Eliya | Gneiss, Fracture zone | 81.0 | 25.7 | 800 | 51.1 | 2.0 |
| TB-3 | Barrack Plain Reservoir Basin / Hawa Eliya | Gneiss, Fracture zone | 44.2 | 13.4 | >1,000 | 230 | 17.2 |

From the result of the test borings (TB-2 and TB-3) in Hawa Eliya, it became clear that predominant aquifer is formed in fissure zone developed in fresh quartzite and limestone layers, which are underlying the weathered gneiss. Since groundwater obtained from the fissure zone in quartzite has more quantity and better quality than that from the weathered formation of gneiss, it was concluded that these fresh quartzite and limestone layers underlying the weathered gneiss is the target formations for the groundwater development in the Study area. Although the test boring in Race Course interrupted drilling at the depth of 104m and has not completed a pumping test by a collapse layer and the drilling capability of the machine, measurements of groundwater yield in the middle of drilling showed that it was about the half of that in Hawa Eliya.

As a result of simulation analysis using the aquifer characteristic value (a permeability coefficient, a transmissivity coefficient, a storage coefficient, layer thickness, diameter of a well) obtained by the pumping test of the test borings, the following values of safety pumping rate are obtained.

| | <Test boring data> | <planned pumping rate> |
|---|---|---|
| Hawa Eliya area | 600～1,400 ($m^3$/day) | 800 ($m^3$/day) |
| Race Course area | 157 ($m^3$/day) | 300 ($m^3$/day) |

Planned pumping rate at Race Course was unfortunately smaller than one in Hawa Eliya and prospected quantity based on the results of the test borings as shown above and additional groundwater development area should be considered. Under this condition, Golf Course, which was confirmed as potential area by the previous JICA Study, became candidate again although this area was once excluded from proposed site because of difficulties of land acquisition. NWSDB as executing agency of the Project stated that land acquisition would be executed by NWSDB's responsibility. Therefore, this Golf Course was included in the proposed site of groundwater development.

Planned pumping rate was estimated as shown below based on data which were obtained by the previous JICA Study and by same simulation conducted for the above two areas.

| | <Safe Yield at Test Well> | <planned pumping rate> |
|---|---|---|
| Golf Course area | 770 ($m^3$/day) | 800 ($m^3$/day) |

Since groundwater yield changes greatly with geological situations, well structures, etc, at a well drilling site, the safety-pumping rate should be decided by the pumping test at each well. On the Basic Design Study, the pumping rate is set a little to the safety side respecting reliability.

### 6) Groundwater Development Plan

The most suitable groundwater development plan was selected from four (4) alternative plans which were prepared based on three (3) possible groundwater development areas mentioned above. Quantity of groundwater and location of receiving groundwater are common to the all alternatives, 4,651 $m^3$/day at Race Course Junction Well for Low Area 1 and 1,744 $m^3$/day at Hawa Eliya Junction Well for Low Area 2.

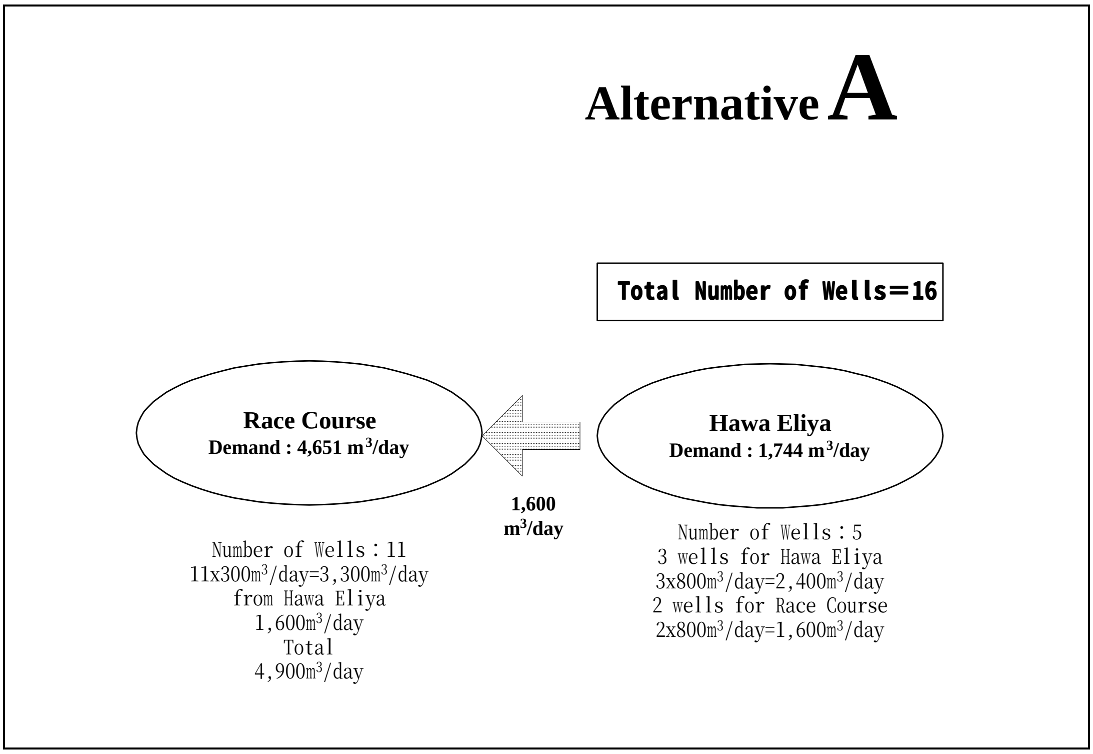
Points listed below were taken into account for preparation of alternatives and for their comparative studies.

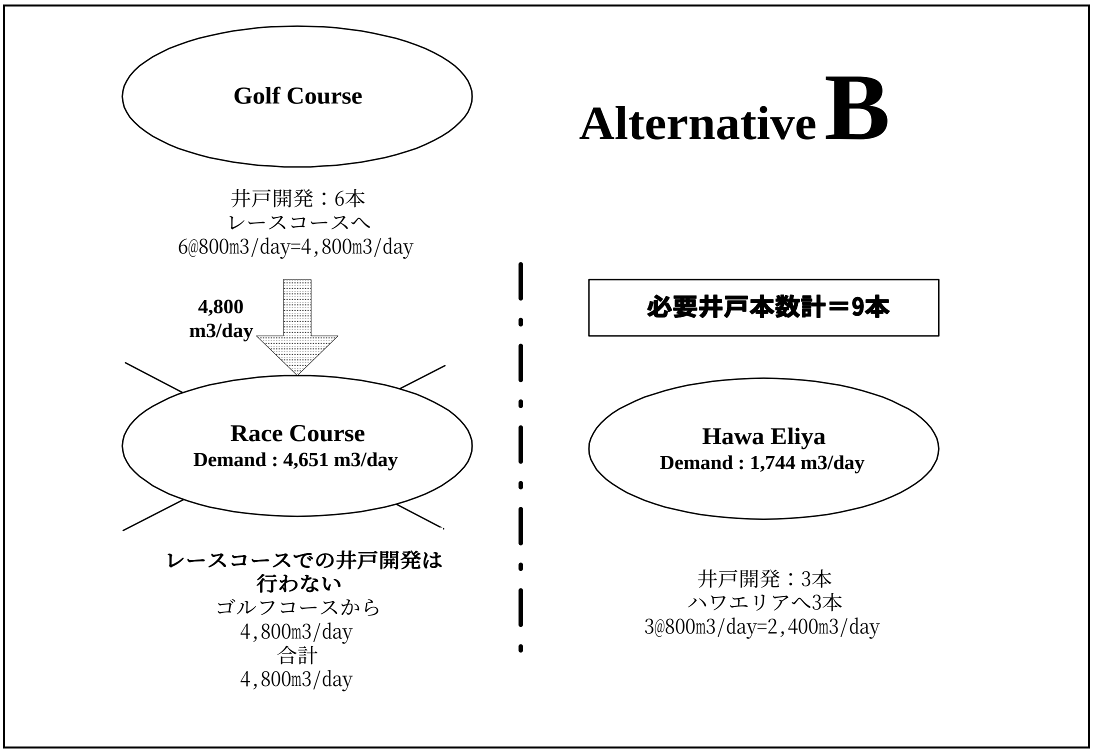
- Quantity of groundwater abstraction shall be less than groundwater recharge in the respective area for sustainable and safe groundwater utilization.
- Utilize groundwater effectively.
- Low construction costs.

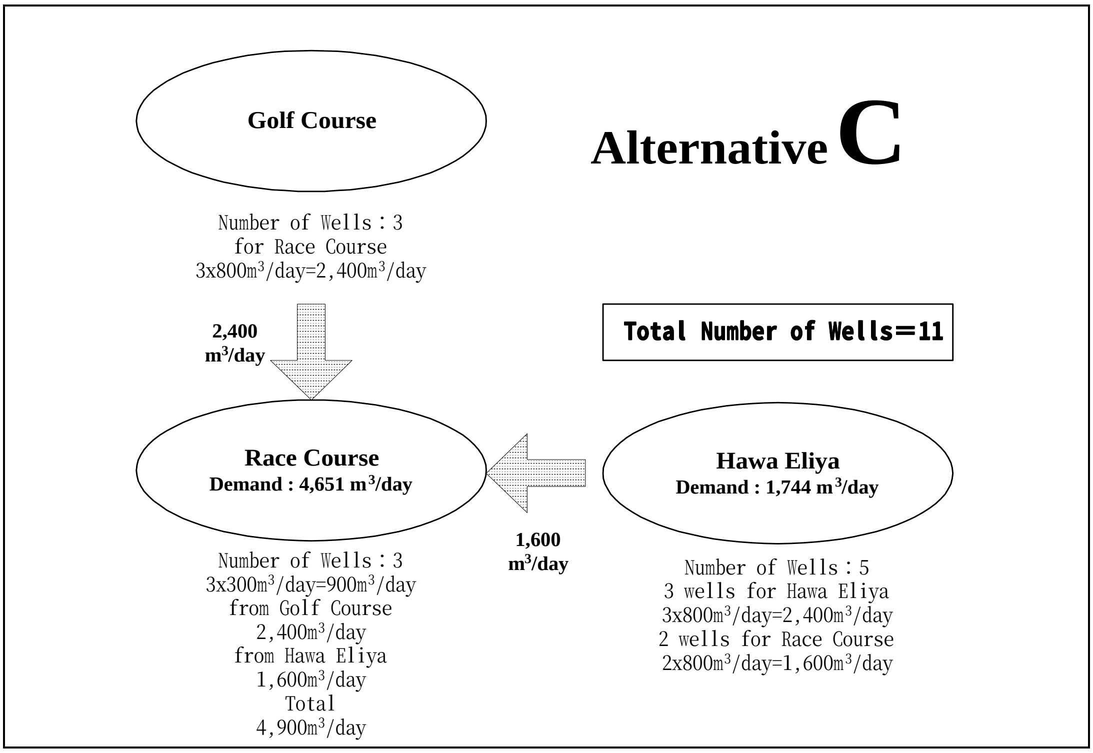
Prepared four alternatives A, B, C, and D are as shown on Figure-**2.11**.

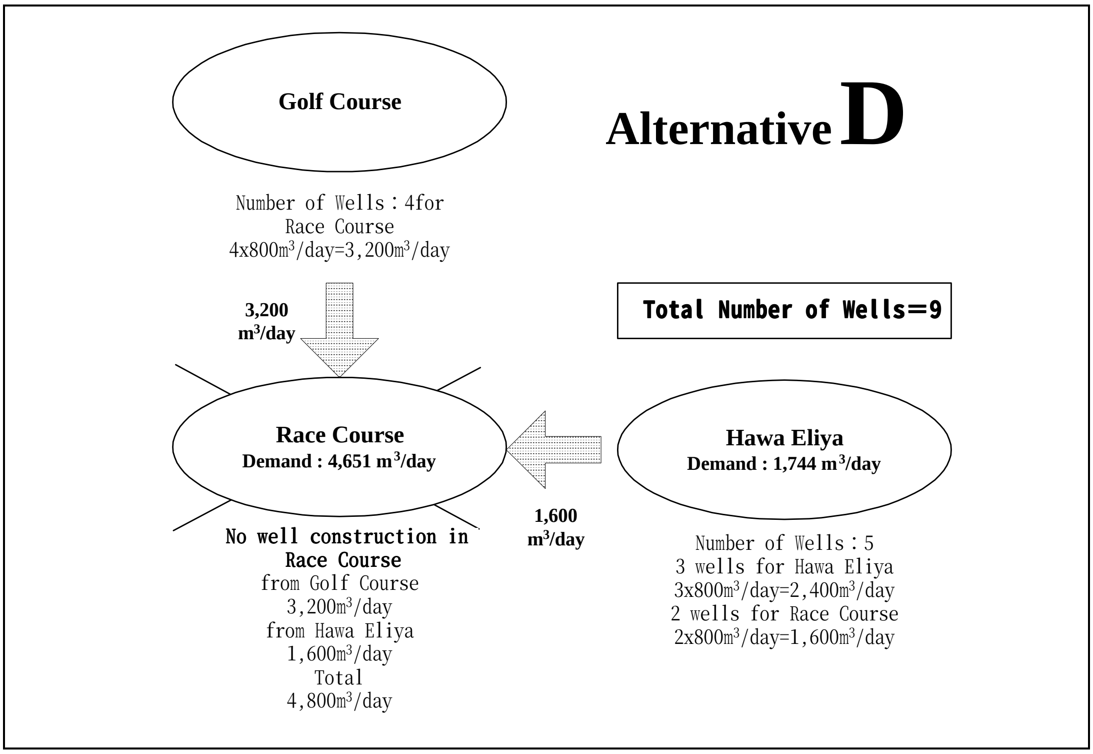
| | |
|---|---|
| Alternative A : | Maximum groundwater development will take place in Race Course area and balance of water will be transmitted from Hawa Eliya. Water required in Hawa Eliya will be supplied by wells in Hawa Eliya. |
| Alternative B : | Three wells will be constructed in Golf Course and balance of water will be supplied by wells constructed in Race Course. Water required in Hawa Eliya will be supplied by wells in Hawa Eliya. No water will be transmitted to Race Course from Hawa Eliya. |
| Alternative C : | Wells will be constructed in Golf Course and Hawa Eliya and groundwater will be transmitted to Race Course. Balance of water will be supplied by wells constructed in Race Course. Water required in Hawa Eliya will be supplied by wells in Hawa Eliya. |
| Alternative D : | Wells will be constructed in Golf Course and Hawa Eliya and groundwater will be transmitted to Race Course. No groundwater development in Race Course will take place. Water required in Hawa Eliya will be supplied by wells in Hawa Eliya. |

**Figure-2.11 Alternatives**




Golf Course
Alternative C
Number of Wells：3
for Race Course
3x800m³/day=2,400m³/day
2,400
m³/day
Total Number of Wells=11
Race Course
Demand : 4,651 m³/day
Hawa Eliya
Demand : 1,744 m³/day
1,600
m³/day
Number of Wells：3
3x300m³/day=900m³/day
from Golf Course
2,400m³/day
from Hawa Eliya
1,600m³/day
Total
4,900m³/day
Number of Wells：5
3 wells for Hawa Eliya
3x800m³/day=2,400m³/day
2 wells for Race Course
2x800m³/day=1,600m³/day


Golf Course
Alternative D
Number of Wells：4for
Race Course
4x800m³/day=3,200m³/day
3,200
m³/day
Total Number of Wells=9
Race Course
Demand : 4,651 m³/day
Hawa Eliya
Demand : 1,744 m³/day
1,600
m³/day
No well construction in
Race Course
from Golf Course
3,200m³/day
from Hawa Eliya
1,600m³/day
Total
4,800m³/day
Number of Wells：5
3 wells for Hawa Eliya
3x800m³/day=2,400m³/day
2 wells for Race Course
2x800m³/day=1,600m³/day

Above four (4) alternatives were compared and results of the comparison are shown on **Table-2.18**.

**Table-2.18　　Results of Comparison**

| Alternatives | Total nunber of Wells | Evaluation from groundwater recharge | Judge | Verification of groundwater system as water source | Judge | Rank of Construction Cost (４：high～１：low) | Judge | Final Judgment |
|---|---|---|---|---|---|---|---|---|
| **A** | 16 | No Problem | ○ | Many inefficient wells should be constructed in Race Course. | × | 4 | △ | △ |
| **B** | 14 | No Problem | ○ | Confirmed groundwater capacity by test Boring cannot be utilized. Many inefficient wells should be constructed in Race Course | △ | 3 | △ | ○ |
| **C** | 11 | No Problem | ○ | Safer system by using three groundwater sources. Inefficient wells should be constructed in Race Course | △ | 2 | ○ | ○ |
| **D** | 9 | No Problem | ○ | Safe system by using two groundwater sources. | ○ | 1 | ◎ | ◎ |

Comparison in terms of operation costs was not considered since elevation of wells, water levels, and transmitting water quantity were almost same among all alternatives. Easiness or difficulties of system operation was also excluded from this comparison since required technical level was same among all alternatives.

From the results of comparison, which are shown on table above, the best alternative is Alternative D and the system is shown on **Figure-2.12**. According to the plan of the Alternative D, groundwater will be abstracted from four (4) wells intensively constructed in Golf Course. Although total quantity of groundwater recharge in the Nanu Oya River Upstream Basin which includes Golf Course is enough against planned abstraction, planned yield might not be expected during severe drought year. In case however, if it may happen, it might be temporal and will not cause serious problem. Distance between each well should be designed with at least 150 m interval to avoid well interference.

As shown on **Figure-2.12**, there are two systems of groundwater transmission. One is Race Course System and the other is Hawa Eliya System. In the Race Course System, groundwater from two (2) wells in Hawa Eliya and four (4) wells in Golf Course is transmitted to J1 Junction Well in Race Course. In the Hawa Eliya System, groundwater from three (3) wells in Hawa Eliya is transmitted to J2 Junction Well in Hawa Eliya.

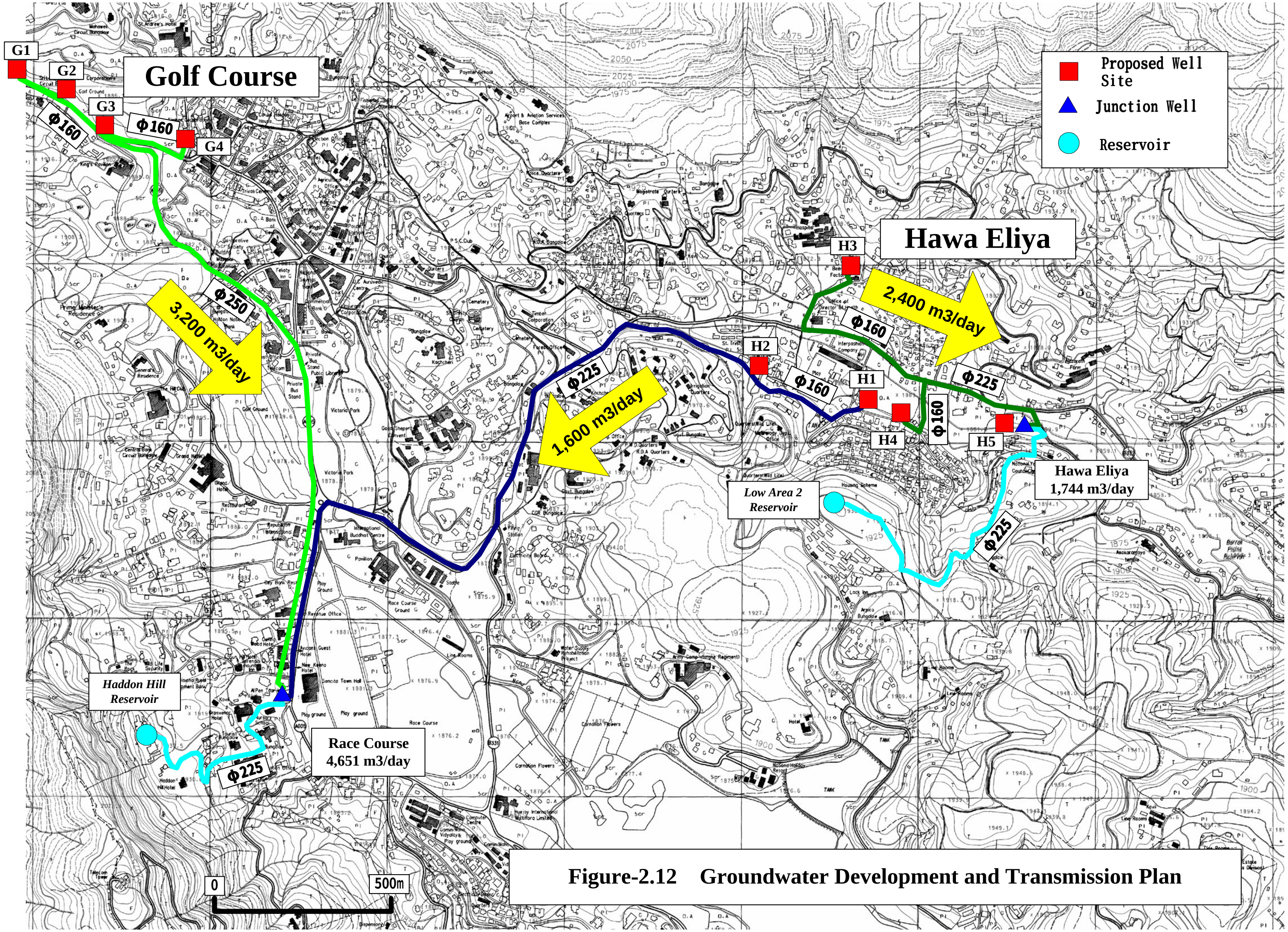
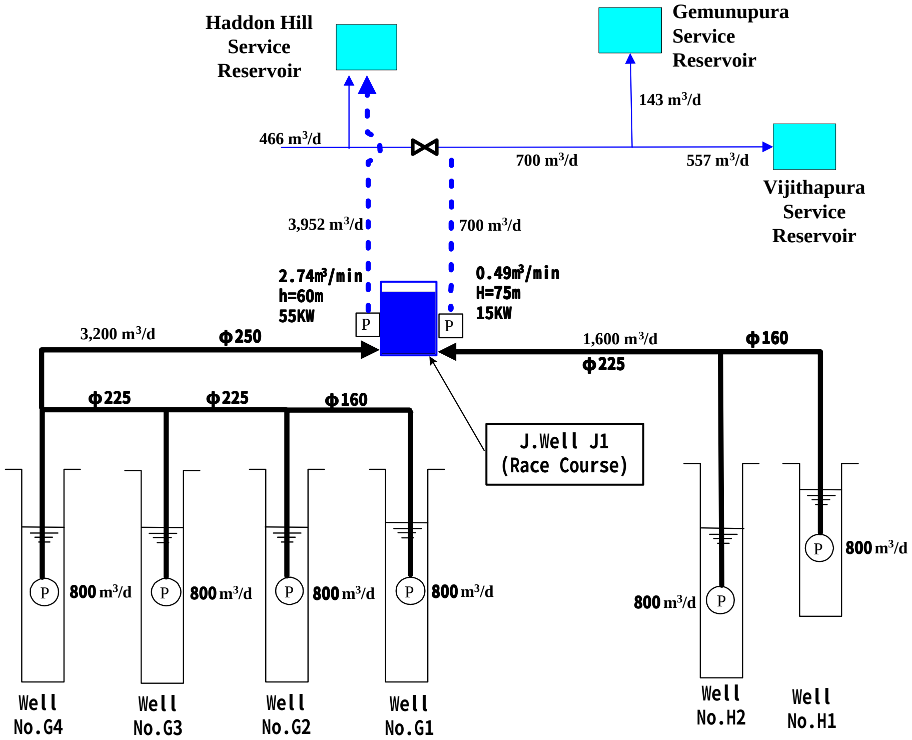



**Figure-2.12 Groundwater Development and Transmission Plan**

### 7) Race Course System




Race Course System includes four wells (@800m$^3$/day x 4 = 3,200 m$^3$/day) in Golf Course and abstracted groundwater from these wells will be transmitted to Junction Well J1 in Race Course. In addition, groundwater from two among five wells (@800m$^3$/day x 2 = 1,600 m$^3$/day) in Hawa Eliya also transmitted to the Junction Well J1. From the Junction Well J1, water will be transmitted by transmission pump to Haddon Hill Reservoir, Gemunupura Reservoir and Vijithapura Reservoir.

#### a) Well Construction

Groundwater is planned to be transmitted to Junction Well J1 in Race Course from four (4) wells in Golf Course and two (2) wells in Hawa Eliya. Minimum distance of 150 m is to be kept between wells in order to minimize the interference on the descent of dynamic groundwater table. The diameter of casing with slit strainer is 8 inches. The depth of each well is assumed as shown in the **Table-2.19**.

**Table-2.19 Depth of Each Well in the Race Course System**

| Well | Depth | Remarks |
|---|---|---|
| Four (4) Wells at Golf Course （G1～G4） | 100 m | 100 m depth is assumed considering the groundwater was obtained at the depth of 88m at a Test Well during the previous JICA Study. |
| A Well at Hawa Eliya (H1) | 60 m | 60 m depth is assumed considering that groundwater gushed out at the depth of about 44m in the Test Boring. |
| A Well at Hawa Eliya (H2) | 100 m | 100 m depth is assumed considering that groundwater gushed out at the depth of about 81m in the Test Boring nearby the H2 site. |

The type of all well pumps is submersible type and these pumps lift groundwater to Junction Well J1 in Race Course through groundwater transmission pipelines. The capacity of each pump is 0.56 $m^3$/minute. Pump head is planned to be 30 m for four (4) pumps in Golf Course and 50 m for H1 pump and 55m for H2 pump in Hawa Eliya considering dynamic groundwater table, water level of Junction Well J1, water head loss in the pipes, and other head losses. The level of dynamic groundwater table is assumed to be 15 m from ground surface at four (4) wells in Golf Course, 10 m at H1 and 25 m at H2 in Hawa Eliya, respectively.

**b) Groundwater Transmission Pipes and Junction Well**

Groundwater is transmitted to Junction Well J1 at Race Course through two groundwater transmission pipelines, one from Golf Course and the other from Hawa Eliya. Installations of well connecting pipes in Golf Course are planned with PVC pipe of diameter 160 mm and 225 mm. 2,299 meter DCIP pipe of diameter 250 mm is planned to install from the connecting pipes in Golf Course to Junction Well J1. From the two wells in Hawa Eliya, 2,406 m of PVC pipe of diameter 225 mm is planed to be installed to the Junction Well J1 in Race Course. The Junction Well J1 is RC structure with the capacity of 30 $m^3$ and will be constructed above the ground. The groundwater transmission pipes to be installed in the Race Course System are summarized in **Table-2.20**.

**Table-2.20 Groundwater Transmission Pipes in the Race Course System**

| Diameter (mm) | Pipe Material | Pipe Length (m) |
|---|---|---|
| 250 | DCIP | 2,299 |
| 225 | PVC | 2,776 |
| 160 | PVC | 772 |
| | Total | 5,847 |

**c) Transmission Pumps**

Transmission Pump House with floor space of 60 $m^2$ is planned to be constructed next to Junction Well J1. Following two types of pumps will be installed.

- For transmission of clear water to Haddon Hill Service Reservoir

  2.74 $m^3$/min x h 60 m x 55 KW x 2 units (one in operation, one on standby)

- For transmission of clear water to Gemunupura/Vijithapura Service Reservoir

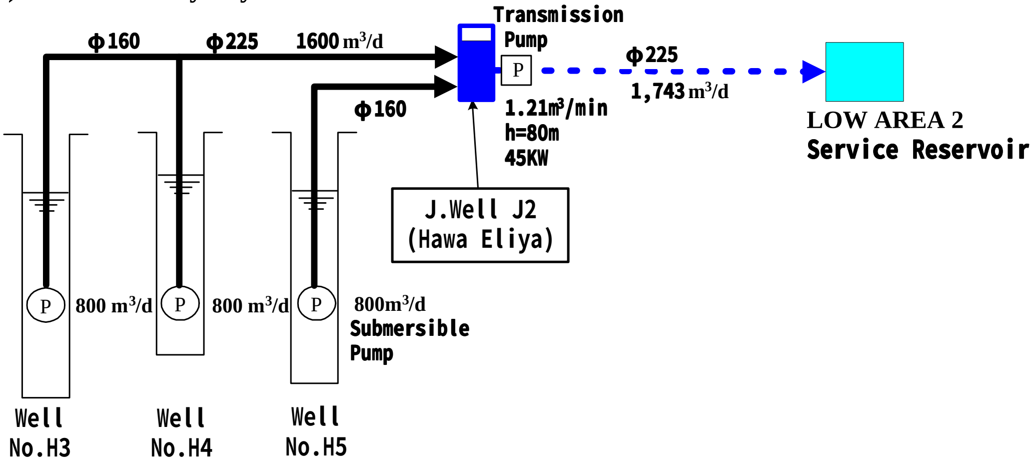
  0.49$m^3$/min x h 75 m x 15 KW x 2 units (one in operation, one on standby)

These pumps will be horizontal volute pumps and will be used only in dry season. In addition to above pumps transmission booster pumps (to Unique View Service Reservoir) will also be installed in this Pump House.

**d) Transmission Pipe**

A new transmission pipeline of PVC 225 mm with the length of 502 m will be laid to lift clear water from Junction Well J1 in Race Course to the existing Haddon Hill Service Reservoir. The same new transmission pipeline, which conveys surface water during the rainy season, will be used to convey groundwater from Junction Well J1 to Gemunupura Service Reservoir and Vijithapura Service Reservoir in dry season.

**8) Hawa Eliya System**




Hawa Eliya System includes three wells (@800$m^3$/day x 3 = 2,400 $m^3$/day) in Hawa Eliya and abstracted groundwater from these wells will be transmitted to Junction Well J2 in Hawa Eliya. From the Junction Well J2, water will be transmitted by transmission pump to Low Area 2 Reservoir.

### a) Well Construction

It is planned to construct three (3) more wells in Hawa Eliya. The groundwater from these three wells will be transmitted to Junction Well J2 in Hawa Eliya. Minimum distance of 150 m is to be kept between wells in order to minimize well interference on the descent of dynamic groundwater level. The size of slit strainer pipe is 8 inches. The depth of each well is summarized in the **Table-2.21**.

**Table-2.21 Depth of Each Well in the Hawa Eliya System**

| Well | Depth | Remarks |
|---|---|---|
| Hawa Eliya (H3) | 100 m | 100 m depth is assumed as same as H2 considering that the location is higher area in Hawa Eliya. |
| Hawa Eliya (H4) | 60 m | 60 m depth is assumed considering that groundwater gushed out at the depth of about 44m in the Test Boring nearby the H4 site. |
| Hawa Eliya (H5) | 80 m | 80 m depth is assumed taking average depth of wells in Hawa Eliya since data are not available for H5. |

The type of all well pumps is submersible type and these pumps lift groundwater to Junction Well J2 in Hawa Eliya through groundwater transmission pipelines. The pump capacity of 0.56 $m^3$/min and pump head of 30m are planned for these three pumps considering dynamic groundwater table, water level of Junction Well J2, water head loss in the pipes and other head losses. The level of dynamic groundwater table is assumed to be 25 m from ground surface at H3, 15 m at H4 and 20 m at H5, respectively.

### b) Groundwater Transmission Pipes and Junction Well

Groundwater is transmitted to Junction Well J2 through two groundwater transmission pipelines, one from H3 and H4 and the other from H5. The groundwater transmission pipe from each well is PVC pipe of diameter 160 mm and PVC pipe of diameter 225 mm is planned to be installed from the connection point of H3 and H4. The Junction Well J2 is RC structure with the capacity of 30$m^3$ and will be constructed above the ground. The groundwater transmission pipes to be installed in the Hawa Eliya System are summarized in **Table-2.22**.

**Table-2.22 Groundwater Transmission Pipes in the Hawa Eliya System**

| Diameter (mm) | Pipe Material | Pipe Length (m) |
|---|---|---|
| 225 | PVC | 358 |
| 160 | PVC | 916 |
| | Total | 1,274 |

**c) Transmission Pump**

It is planed to construct Transmission Pump House with the floor space of 36 $m^2$ next to Junction Well J2. The following pumps are to be installed to transmit clear water to Low Area 2 Service Reservoir.

1.21$m^3$/min x h 80 m x 45 KW x 2 units (one in operation, one on standby)

These pumps will be horizontal volute pumps and will not be used in rainy season.

**d) Transmission Pipe**

A new transmission pipeline of PVC 225 mm with the length of about 760 m will be laid to lift clear water from Junction Well J2 in Hawa Eliya to the new Low Area 2 Service Reservoir. The transmission pipe will be installed under the shallow road on the mountain and a path in tea fields. The pipe under this path is also used to transmit surface water during rainy season.

## (2) Transmission and Distribution Facilities

### 1) Water Quality

In this Basic Design Study, water quality analysis was conducted for confirmation of water quality sampled at nine surface water sources and two groundwater sources where the previous JICA Study did the analysis. The results are summarized in **Table-2.23**. Drinking Water Quality Standard by NWSDB is to satisfy WHO Guidelines, which are also shown in the same table.

Total coliforms and faecal coliforms were found in seven samples and in three samples respectively by the analysis, though total coliforms and faecal coliforms must not be detected in any 100-ml sample according to WHO Guideline values for drinking-water quality (hereinafter called as Guideline value). The standard values can be satisfied by conducting chlorination properly.

Although the sampling from these nine surface water sources was conducted during rain, turbidity of all the samples were low, same as the result of analysis done by the previous JICA Study in rainy season. Turbidity of Pedro water sources sometimes shows high during rain according to Nuwara Eliya Waterworks. In such case, water is to be filtered in the pressure filters installed near Victoria Park. **Table-2.23** also shows the results of water quality analysis at Golf Course test well conducted by the previous JICA Study. Comparing with other water quality of surface water, although some index show high value, they are still in the range of drinking water quality guideline and there would be no problem as a water source. Turbidity shows maximum value of guideline, this may be resulted from insufficient flushing the test well.

From the above consideration, only chlorination is required as disinfection purpose in ordinary case for usage of the existing surface water sources and groundwater sources.

**Table-2.23 (1) Results of Water Quality Analysis**

| Item | | Temp. | Turb. | Color | pH | Cond. | TDS | SS | Alkalinity | $BOD_5$ | KMnO4 Consump. | $NH_3^+$ | $NO_2^-$ | $NO_3^-$ | $PO_4^{3-}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unit | | ℃ | NTU | TCU | - | μ s/cm | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l |
| WHO Guideline | | - | 5 | 15 | - | - | 1000 | - | - | - | - | - | 3 | 50 | - |
| | | | | | | | | | | | | | | | |
| 1 | Bambarakele | 18.0 | 0.98 | 11 | 8.60 | 1.1 | 18 | <1 | 20 | 0.93 | 3.20 | 0.01 | 0.004 | 0.60 | 0.51 |
| 2 | Shanthipura | 17.0 | 0.77 | 0 | 9.00 | 1.5 | 22 | <1 | 36 | 1.74 | 1.50 | 0.02 | 0.004 | 1.40 | 0.07 |
| 3 | Pedro | 15.0 | 0.43 | 2 | 9.20 | 17.0 | 36 | <1 | 22 | 0.45 | 3.00 | 0.05 | 0.003 | 0.90 | 0.01 |
| 4 | New Water Field | 17.0 | 1.55 | 15 | 9.60 | 1.6 | 26 | <1 | 12 | 1.46 | 5.30 | 0.01 | 0.007 | 0.60 | 0.03 |
| 5 | Old Water Field | 15.0 | 0.74 | 10 | 9.10 | 25.0 | 28 | <1 | 42 | 2.01 | 4.00 | 0.02 | 0.005 | 0.50 | 0.01 |
| 6 | Piyatissapura | 19.0 | 1.23 | 0 | 8.70 | 1.7 | 72 | 1.4 | 24 | 0.00 | 5.10 | 0.01 | 0.004 | 0.60 | 0.66 |
| 7 | Brewery | 15.0 | 0.75 | 12 | 8.70 | 55.0 | 44 | <1 | 42 | 1.15 | 6.30 | 0.02 | 0.000 | 0.70 | 0.01 |
| 8 | Gamunu | 15.0 | 0.63 | 14 | 8.90 | 50.0 | 46 | <1 | 14 | 0.85 | 8.00 | 0.02 | 0.011 | 0.80 | 0.01 |
| 9 | Lover's Leap | 16.0 | 1.04 | 14 | 8.30 | 11.0 | 72 | <1 | 12 | 5.40 | 5.80 | 0.00 | 0.004 | 0.60 | 0.03 |
| G1 | Bonavista | 18.6 | 0.36 | 0 | 8.80 | 225.0 | 174 | <1 | 288 | 0.40 | 1.00 | 0.00 | 0.007 | 1.20 | 1.77 |
| G2 | Upper Lake | 18.0 | 0.10 | 7 | 7.40 | 85.0 | 75 | <1 | 93 | 1.60 | 0.90 | 0.00 | 0.003 | 1.80 | 0.04 |
| G3 | Golf Course | 17.3 | 5.00 | NA | 9.40 | 230.0 | 115 | NA | 151 | NA | NA | 0.05 | 0.090 | 2.38 | 0.68 |

| Item | | T Phos. | $SO_4^{2-}$ | $CN^-$ | Fe | Mn | $F^-$ | As | Cr | Cu | Cd | Hg | Pb | T Coli* | F coli* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unit | | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | CFU/100ml | CFU/100ml |
| WHO Guideline | | - | - | 0.07 | 0.3 | 0.5 | 1.5 | 0.01 | 0.05 | 2 | 0.003 | - | 0.01 | - | ND |
| | | | | | | | | | | | | | | | |
| 1 | Bambarakele | 0.51 | 0.0 | ND | 0.08 | 0.000 | 0.27 | ND | <0.02 | 0.0 | ND | ND | ND | 4.0E+00 | 3.0E+00 |
| 2 | Shanthipura | 0.10 | 1.0 | ND | 0.01 | 0.000 | 0.00 | ND | <0.02 | ND | ND | ND | ND | ND | ND |
| 3 | Pedro | 0.01 | 1.0 | ND | 0.01 | 0.001 | 0.00 | ND | <0.02 | ND | ND | ND | ND | 1.2E+02 | ND |
| 4 | New Water Field | 0.03 | 1.0 | ND | 0.04 | 0.000 | 0.12 | ND | <0.02 | 0.0 | ND | ND | ND | 2.0E+01 | 1.6E+01 |
| 5 | Old Water Field | 0.01 | 4.0 | ND | 0.02 | 0.000 | 0.35 | ND | <0.02 | ND | ND | ND | ND | 2.2E+01 | ND |
| 6 | Piyatissapura | 0.68 | 1.0 | ND | 0.03 | 0.000 | 0.12 | ND | <0.02 | ND | ND | ND | ND | ND | ND |
| 7 | Brewery | 0.05 | 1.0 | ND | 0.08 | 0.210 | 0.21 | ND | <0.02 | ND | ND | ND | ND | 7.8E+01 | ND |
| 8 | Gamunu | 0.01 | 1.0 | ND | 0.04 | 0.000 | 0.05 | ND | <0.02 | 0.0 | ND | ND | ND | 5.0E+00 | ND |
| 9 | Lover's Leap | 0.04 | 0.0 | ND | 0.06 | 0.013 | 0.17 | ND | <0.02 | ND | ND | ND | ND | 1.6E+01 | 9.0E+00 |
| G1 | Bonavista | 1.84 | 5.0 | ND | 0.02 | 0.002 | 0.15 | ND | <0.02 | ND | ND | ND | ND | 4.5E+01 | 2.6E+01 |
| G2 | Upper Lake | 0.07 | 4.0 | ND | ND | 0.000 | 0.33 | ND | <0.02 | ND | ND | ND | ND | ND | ND |
| G3 | Golf Course | NA | 2.0 | ND | ND | ND | 0.18 | ND | ND | ND | ND | ND | ND | 2.0E+01 | ND |

Note: ND - Not detected, NA - Not Available, hyphen - Not in Standard

**Table 2.23 (2) Reseults of Water Quality Analysis (Pesticides)**

| Item | | d HCH | Aldrin | Dieldrin | DDT | Malathion | Parathion | Alachlor |
|---|---|---|---|---|---|---|---|---|
| Unit | | mg/l | μ g/l | μ g/l | mg/l | mg/l | mg/l | μ g/l |
| WHO Guideline | | – | 0.03 | 0.03 | 2 | – | – | 20 |
| | | | | | | | | |
| 1 | Bambarakele | ND | ND | ND | ND | ND | ND | ND |
| 2 | Shanthipura | ND | ND | ND | ND | ND | ND | ND |
| 3 | Pedro | ND | ND | ND | ND | ND | ND | ND |
| 4 | New Water Field | ND | ND | ND | ND | ND | ND | ND |
| 5 | Old Water Field | ND | ND | ND | ND | ND | ND | ND |
| 6 | Piyatissapura | ND | ND | ND | ND | ND | ND | ND |
| 7 | Brewery | ND | ND | ND | ND | ND | ND | ND |
| 8 | Gamunu | ND | ND | ND | ND | ND | ND | ND |
| 9 | Lover's Leap | ND | ND | ND | ND | ND | ND | ND |
| G1 | Bonavista | ND | ND | ND | ND | ND | ND | ND |
| G2 | Upper Lake | ND | ND | ND | ND | ND | ND | ND |
| G3 | Golf Course | NA | NA | NA | NA | NA | NA | NA |

Note: ND - Not detected, NA - Not Available, hyphen - Not in Standard
Turb., SS, KMnO4 Consumption and Cr were analysed in Japan by sampling in December 2000.
The others were analysed in Sri Lanka by sampling in September 2000.
G1, G2, G3 are for ground water and the others are for surfacee water.
The data for G3 are the analysis results by the Previous JICA Study.

### 2) Supply Block

Groundwater is used to supplement shortage of surface water in dry season, which is though sufficient in rainy season. Although water source changes and different water transmission system is required depending on seasonal operation, supply block boundary remains the same.

The service area was planned in the previous JICA Study to be separated into five supply blocks, namely High Area 1, High Area 2, Low Area 1, Low Area 2 and Bonavista Supply Blocks. High Area 1 Supply Block was revised in this Study to be separated into three sub-blocks in order to reduce the number of service reservoirs in each block and to make more simple water supply system. Water sources and service reservoirs for each supply block are summarized in **Table-2.24**.

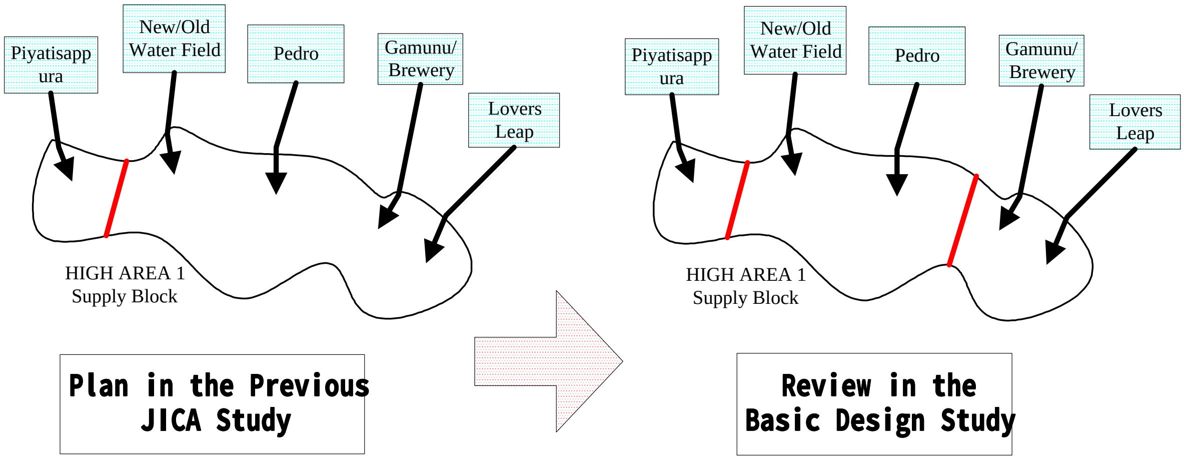
**Table-2.24 Relation of Supply Block, Service Reservoir and Water Sources**

| Supply Block | Service Reservoir | Water Resource in Rainy season | Water Resource in Dry Season | Remarks |
|---|---|---|---|---|
| High Area 1-1 | Piyatisappura | Transmit from Piyatisappura Intake | Same as Rainy season | |
| High Area 1-2 | New Water Field, Old Water Field, Pedro | Transmit to each service reservoir from New Water Field, Old Water Field and Pedro Intakes | Same as Rainy season | |
| High Area 1-3 | Gamunu, Lover's Leap | Transmit from Gamunu and Brewery Intake to Gamunu Service Reservoir. Transmit to Lover's Leap Reservoir from Lover's Leap Intake. | Same as Rainy season | |
| High Area 2 | Naseby | Transmit from Bambarakele and Pedro Intakes via. Booster Pump. | Transmit groundwater from existing Upper Lake Road well. | Existing Well will be used in dry season. |
| Low Area 1 | Haddon Hill | Transmit from Bambarakele and Pedro Intakes | Transmit groundwater from New Wells in Golf Course and Hawa Eliya in addition to transmission from Bambarakele Intake. | New Wells will be used in dry season. |
| Low Area 2 | Low Area 2 | Transmit from Bambarakele and Pedro Intakes | Transmit groundwater from New Wells in Hawa Eliya. | New Wells will be used in dry season. |
| Bonavista | Bonavista | Transmit from Bambarakele and Pedro Intakes | Transmit groundwater from existing Race Course well. | Existing Well will be used in dry season. |
| Unique View | Unique View | Transmit from Bambarakele and Pedro Intakes via. Booster Pump. | Transmit from Bambarakele Intake via. Booster Pump. | Surface water from Pedro Intake will not be used in dry season. |
| Gemunupura | Gemunupura | Transmit from Bambarakele and Pedro Intakes via. Booster Pump | Transmit groundwater from New Wells in Golf Course and Hawa Eliya via. Transmission Pump. | New Wells will be used in dry season. |
| Vijithapura | Vijithapura | Transmit from Bambarakele and Pedro Intakes via. Booster Pump | Transmit groundwater from New Wells in Golf Course and Hawa Eliya via. Transmission Pump. | New Wells will be used in dry season. |

Supply blocks are reviewed to construct simpler water supply system for simple and easy operation. By reducing the number of service reservoirs in each supply block and keeping the same supply block boundary throughout the year, it will becomes easy to have data on the difference of supply volume and consumption in each supply block. This information will help to prioritize the block suffering from high rate of unaccounted-for water and to make effective and efficient unaccounted-for water reduction programs.

Elimination of negative water pressure in distribution pipes (during hourly maximum demand) is also considered in revision of supply block boundary. The concept of separation of High Area-1 supply block is shown in **Figure-2.13** and the boundary of Supply Block is shown in **Figure-2.14**.

**Figure-2.13 Conceptual Drawing of Supply Block Revision**




**High Area 1 (Dry Season)**

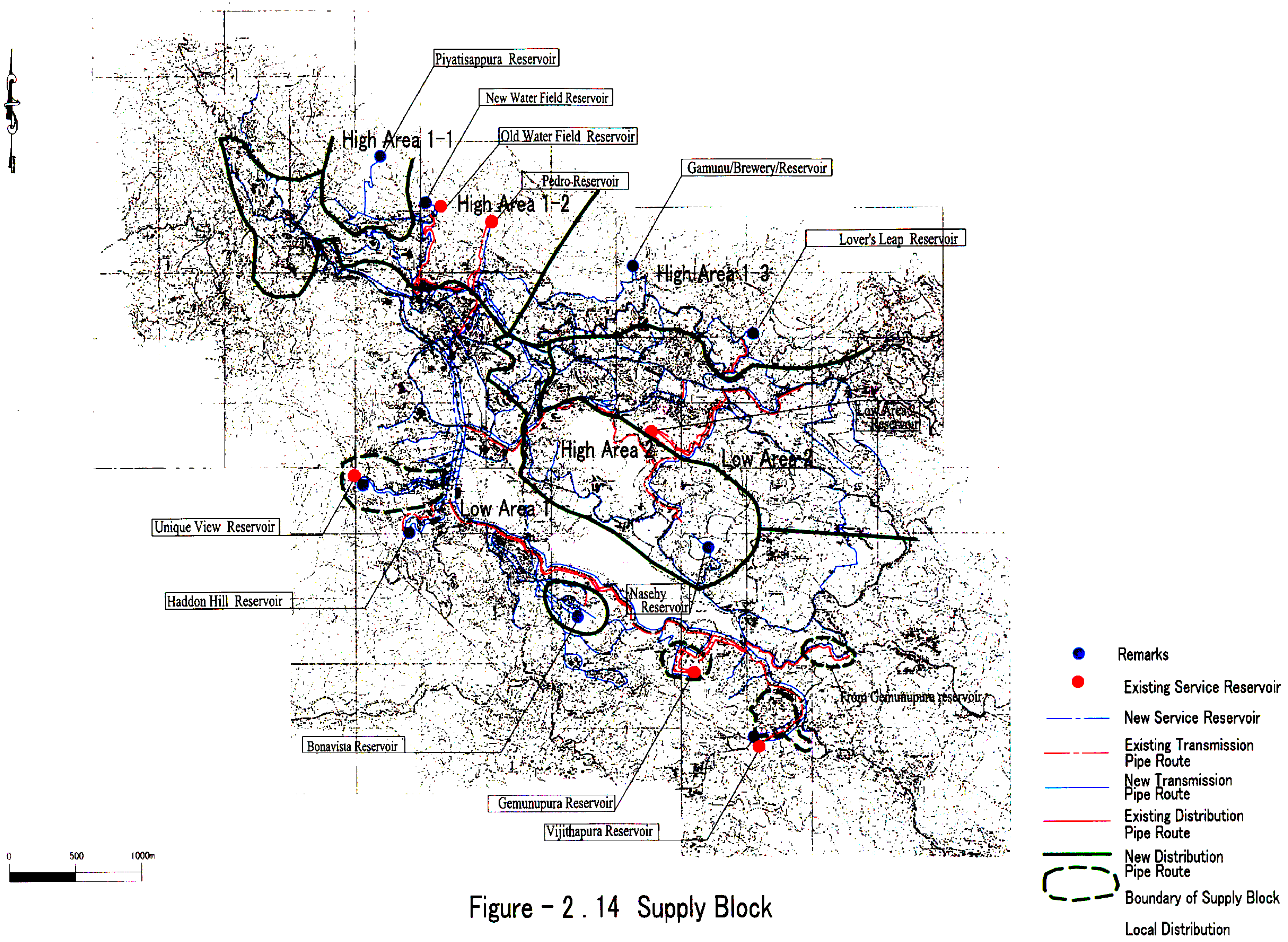
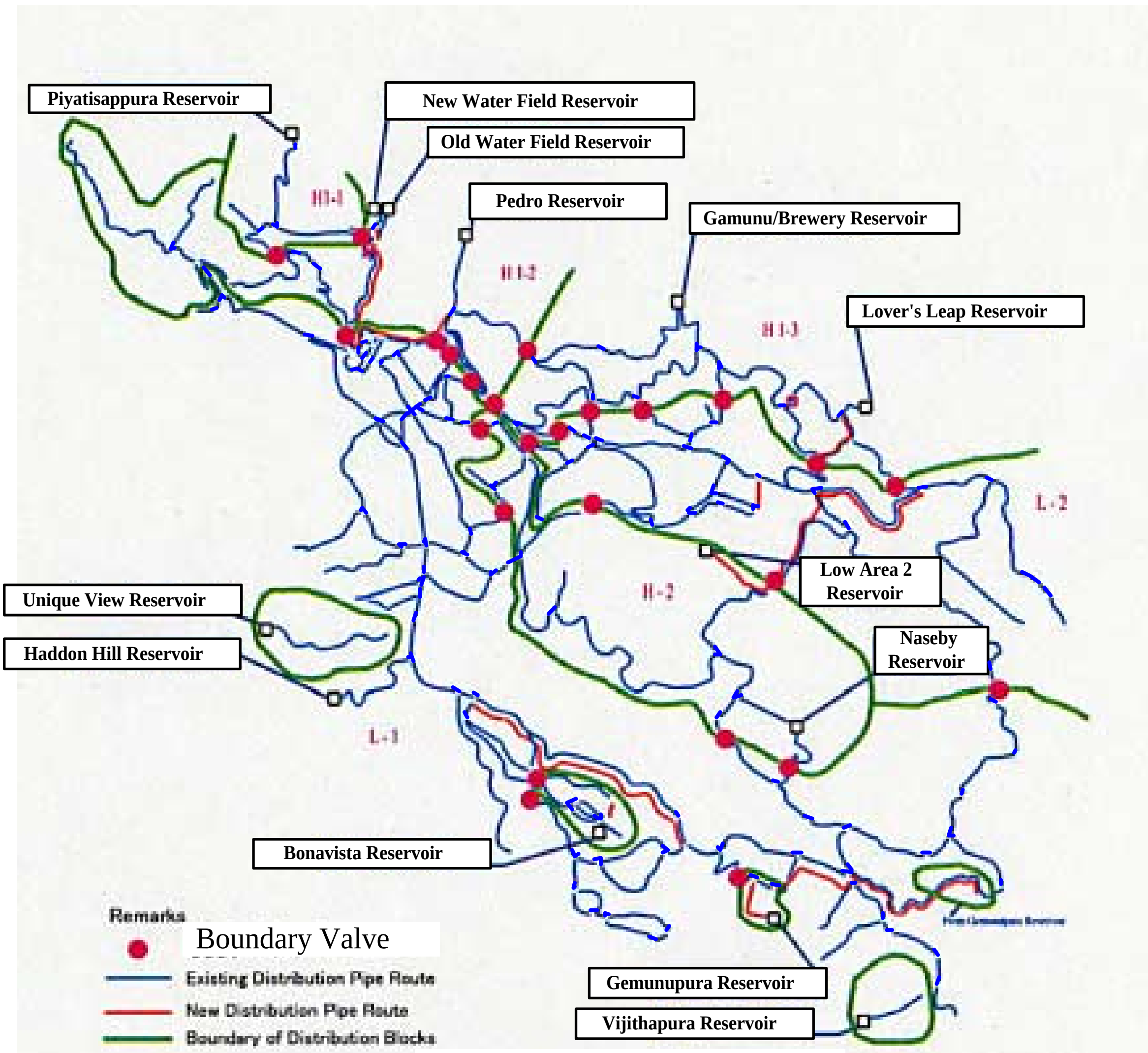



Figure - 2 . 14 Supply Block

Sluice valves are required to be installed on the existing pipes to separate each supply block. These valves are summarized in **Table-2.25**. Location of these boundary valves are shown on figure below.

**Table-2.25 Required Valves on Supply Block Boundary**

| Diameter(mm) | Pipe Material | Number of location |
|---|---|---|
| 50 | PVC | 3 |
| 50 | CI | 1 |
| 75 | PVC | 3 |
| 75 | CI | 1 |
| 100 | CI | 10 |
| 100 | DCIP | 1 |
| 110 | PVC | 1 |
| 150 | CI | 3 |
| 160 | PVC | 1 |
| 225 | PVC | 1 |




Location of Boundary Valve

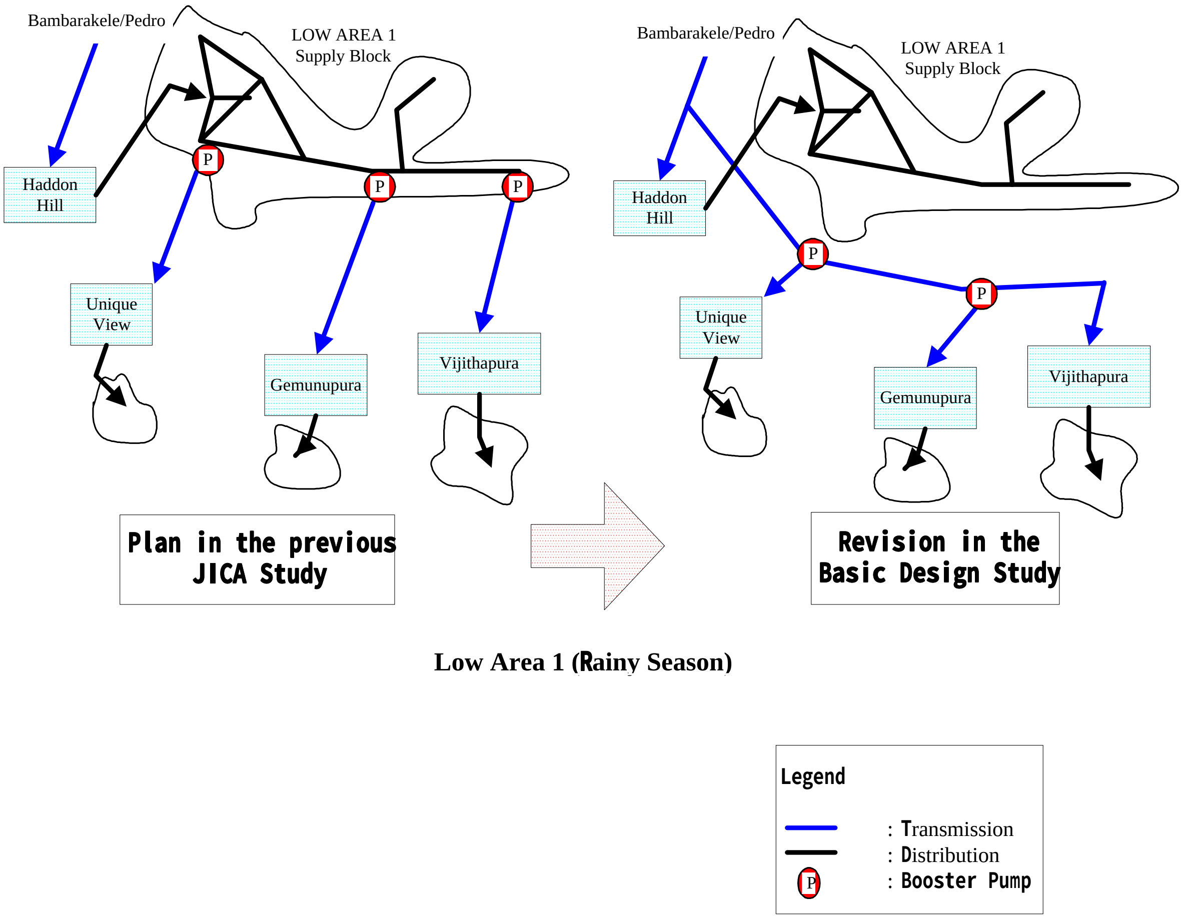
### 3) Transmission Facilities

For transmission of surface water in rainy season, gravity system is applied as much as possible. The change in water transmission system due to usage of groundwater in dry season will be done by operation of valves to be installed on transmission pipelines.

It is planned to transmit groundwater to service reservoirs for High Area 2, Low Area 2 and Bonavista Supply Block in dry season, while surface water is to be transmitted to these service reservoirs in rainy season. Surface water from Bambarakele Intake and Pedro Intake is transmitted to service reservoirs for Low Area 1 in rainy season while surface water from Bambarakele Intake and groundwater from Race Course System is transmitted to them in dry season. Surface water from Pedro Intake is transmitted only to Pedro Reservoir in dry season.

The previous JICA Study planned to distribute water from Haddon Hill Service Reservoir to Low Area 1 Supply block and at the same time to transmit the water to Unique View Service Reservoir and Vijithapura Service Reservoir via same distribution pipeline. This system required complicated operation and had high possibility of negative pressure occurrence in distribution pipes. It is, therefore, planned to separate water transmission system from distribution and to transmit water from Bambarakele Intake and Pedro Intake to these reservoirs by reinforcing transmission pipes in order to make the system more reliable and stable with easier operation. Water will also be transmitted to newly planed Gemunupura Service Reservoir through this transmission system. The Concept of this idea is shown in **Figure-2.15**.

**Figure-2.15 Concept of Distribution / Transmission System Revision (Low Area 1)**




**Low Area 1 (Rainy Season)**

For improvement of transmission system, it is considered to make maximum use of the existing pipes. The exiting groundwater transmission pipes from exiting wells to Bonavista Service Reservoir and High Area 2 Service Reservoir will also be used for surface water transmission in rainy season. Hydraulic analysis is conducted to confirm pipe diameter, booster pump head required, and others. List of new transmission pipes is shown in **Table-2.26** and location of transmission facilities are summarized in **Figure-2.16**.

**Table-2.26**

**List of Proposed Transmission Pipe**

| Dia.(mm) | Material | Length(m) |
|---|---|---|
| 75 | PVC | 468 |
| 110 | PVC | 963 |
| 160 | PVC | 1,115 |
| 225 | PVC | 4,252 |
| 250 | DCIP | 2,175 |
| 300 | DCIP | 983 |
| | Total | 9,956 |

The specification of Booster pumps are summarized in **2-2-2-3 Equipment Plan**.

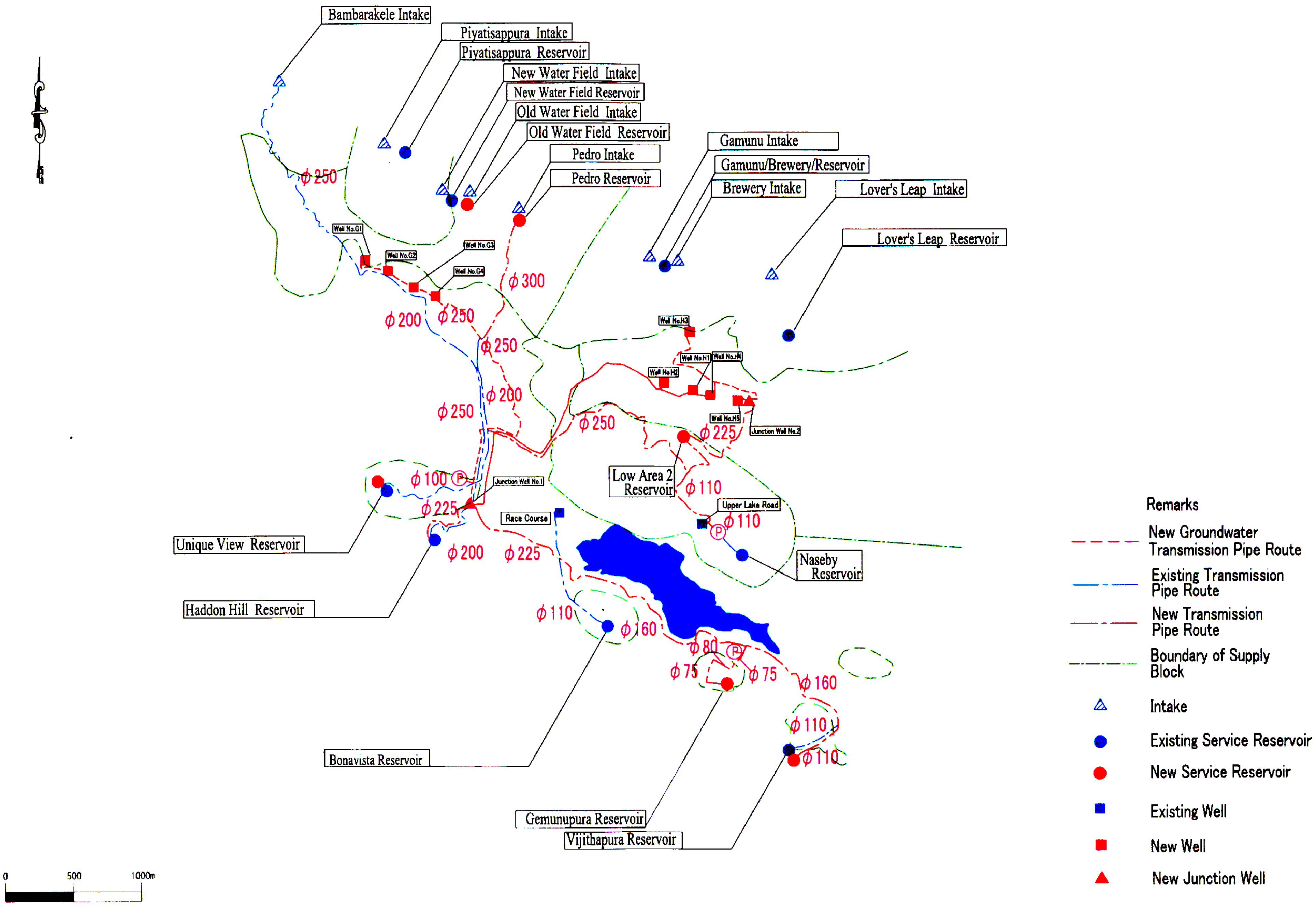



Figure - 2 . 16 Transmission Facilities Location Map

### 4) Service Reservoir

The required capacity of a service reservoir is more than six hour-demand of Day Maximum Water Demand. The capacities of respective reservoirs are reviewed according to the revision of supply block boundary, which was considered based on water demand allocation and available water sources in dry and rainy seasons. The new reservoirs are planed to supplement the shortage of existing reservoir capacities.

**Table-2.27** shows reservoirs for each sub-block and the required capacities.

The following six new reservoirs are required.

- Water is distributed directly from Old Water Field Intake and Pedro Intake at present. New service reservoirs will be constructed for both sites to absorb hourly demand fluctuation and to minimize the affect of facility accidents as planned in the previous JICA Study.
- A new service reservoir is required to be constructed for Low Area 2 Supply Block.
- Capacity of Unique View Service Reservoir and Vijithapura Service Reservoir should be expanded to cope with future water demand increase.
- Gemunupura Service Reservoir will be constructed to supply water to the new area with high elevation in Gemunupura and to highland at northeast of Gregory Lake to increase supply pressure.

Water distribution system is shown in **Figure-2.23** and concept of distribution system in dry season and rainy season is summarized in previous **Figure-2.4** and **Figure-2.5,** respectively.

Four service reservoirs, namely Old Water Field, Pedro, Gemunupura and Low Area 2 Service Reservoir, will be newly constructed and two, namely Unique View and Vijithapura Service Reservoir, will be expanded. The relation of water sources and distribution area of each reservoir are schematically drawn in figures from **Figure-2.17** to **Figure-2.22**.

Among the above six service reservoirs, Low Area 2 reservoir will be consist of 2 basins for easy maintenance and the others will have one basin with a bypass pipe. Pedro Service Reservoir is an elevated tank and RC structure is selected considering easy operation and maintenance and its construction cost, etc.

Land acquisition required for construction of reservoirs is responsible by Sri Lanka side. According to the information from Sri Lanka side in June 2001, the land acquisition was in progress and would be completed in November 2001 before commencement of detailed design.

**Table-2.27 Supply Block, Water Resource, Day Maximum Demand and Reservoir Capacity**

| Supply Block | Name of Water Sources | | Yield Capacity($m^3$/d) | | | Day Max Demand | | Reservoir Capacity | | | Size of Reservoir | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| and | | | Rain | Dry | | 2015($m^3$/d) | | require | Exist. | New | L | W | h |
| Service Reservoir | Rainy season | Dry Season | Exist. | Exist. | New | Rain | Dry | ($m^3$) | ($m^3$). | ($m^3$) | (m) | (m) | (m) |
| High Area 1-1 | | | | | | | | | | | | | |
| Piyatisappura | Piyatisappura | Piyatisappura | 1,080 | 255 | - | 184 | 184 | 46 | 190 | - | - | - | - |
| High Area 1-2 | | | | | | | | | | | | | |
| Old Water Field | Old Water Field | Old Water Field | 3,050 | 290 | - | 423 | 290 | 106 | 0 | 110 | 6.4 | 6.4 | 2.7 |
| New Water Field | New Water Field | New Water Field | 630 | 120 | - | 280 | 120 | 70 | 70 | - | | | |
| Pedro | Pedro | Pedro | 203 | 651 | - | 203 | 496 | 124 | 0 | 130 | 7.5 | 7.5 | 2.4 |
| High Area 1-3 | | | | | | | | | | | | | |
| Gamunu/Brewery | Gamunu/Brewery | Gamunu/Brewery | 2,380 | 447 | - | 447 | 447 | 112 | 190 | - | - | - | - |
| Lovers Leap | Lovers Leap | Lovers Leap | 1,615 | 255 | - | 231 | 231 | 58 | 900 | - | - | - | - |
| Sub-Total(High Area1) | | | 8,958 | 2,018 | | 1,768 | 1,768 | - | - | - | - | - | - |
| Low Area 1 | | | | | | | | | | | | | |
| Haddon Hill | Bambarakele/Pedro | Bambarakele/New Well | 4,635 | 424 | 4,211 | 4,635 | 4,635 | 1,159 | 1800 | - | - | - | - |
| Unique View | Bambarakele/Pedro | Bambarakele | 903 | 903 | - | 903 | 903 | 226 | 40 | 190 | 9.4 | 5.8 | 3.5 |
| Vijithapura | Bambarakele/Pedro | New Well | 584 | 0 | 584 | 584 | 584 | 146 | 40 | 110 | 5.7 | 3.9 | 5.0 |
| Gemunupura | Bambarakele/Pedro | New Well | 150 | 0 | 150 | 150 | 150 | 38 | 0 | 40 | 4.0 | 4.0 | 2.55 |
| Sub-Total(Low Area1) | | | 6,272 | 1,327 | 4,945 | 6,272 | 6,272 | - | - | - | - | - | - |
| Lower Area 2 | Bambarakele/Pedro | New Well | 1,828 | 0 | 1,828 | 1,828 | 1,828 | 457 | 0 | 460 | 10.0 | 15.4 | 3.0 |
| High Area 2(Naseby) | Bambarakele/Pedro | Existing Well(Upper Lake Road) | 589 | 600 | - | 589 | 589 | 147 | 190 | - | - | - | - |
| Bonavista | Bambarakele/Pedro | Existing Well(Race Course) | 243 | 300 | - | 243 | 243 | 61 | 110 | - | - | - | - |
| Total | | | 17,890 | 4,245 | 6,773 | 10,700 | 10,700 | - | - | - | - | - | - |

Number of basins, capacity, type of structure, and accessibility during construction period for each reservoir are summarized in **Table-2.28**.

**Table-2.28 Service Reservoir**

| Name of Service Reservoir | No. of basin | Capacity ($m^3$) | New/ Expansion | Structure | Accessibility during construction |
|---|---|---|---|---|---|
| Old Water Field | 1 | 110 | New | RC. Above ground | Bad* |
| Pedro | 1 | 130 | New | RC. Elevated tank | Bad* |
| Unique View | 1 | 190 | Expansion | RC. Above ground | Normal |
| Vijithapura | 1 | 110 | Expansion | RC. Above ground | Bad* |
| Low Area 2 | 2 | 460 | New | RC. Above ground | Path in tea field |
| Gemunupura | 1 | 40 | New | RC. Above ground | Bad* |

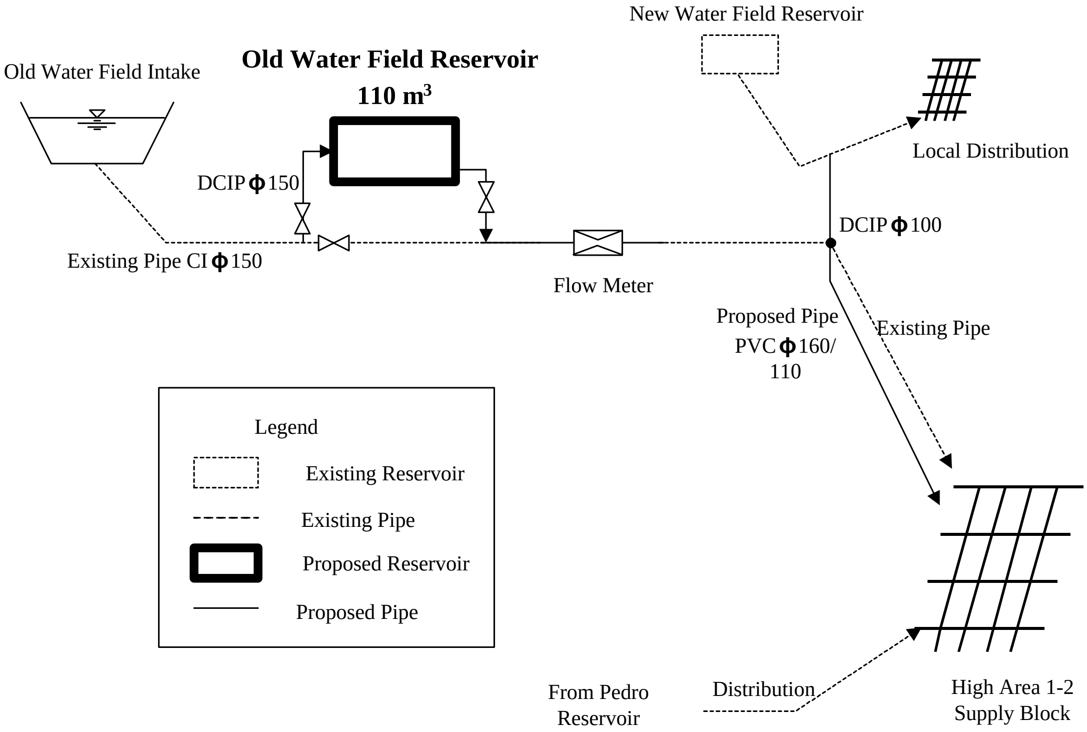
Note） Bad＊ ：The service reservoir construction site cannot be accessible by vehicles. Manual transportation of materials shall be employed.

A flow meter and a control valve are to be installed at the outlet of each service reservoir in order to know the condition of operation and to carry out proper control. Waltman type flow meter will be used to measure accumulated flow rate.

Because of reviewing boundaries of water supply block, capacity of existing reservoir, Lover’s Leap and Haddon Hill Reservoirs, became equivalent to more than 6 hours of distribution quantity. This capacity will be fully utilized to substitute water when accident occurs and will increase system stability.

**Figure-2.17 Old Water Field Reservoir**

- Receive surface water from Old Water Field Intake
- Supply to High Area 1-2 Supply Block together with New Water Field and Pedro Reservoirs
- Capacity of new reservoir is 110 $m^3$ to supply water 403 $m^3$/day and 276 $m^3$/day in rainy and dry seasons respectively



## Figure-2.18 Pedro Reservoir (Elevated)

- Receive surface water from Pedro Intake. In rainy season, supply water except High Area 1
- Supply to High Area 1-2 Supply Block together with Old/New Water Field Reservoirs
- Capacity of new eleveated reservoir is 130 $m^3$ to supply water 194$m^3$/day and 474$m^3$/day in rainy and dry seasons respectively

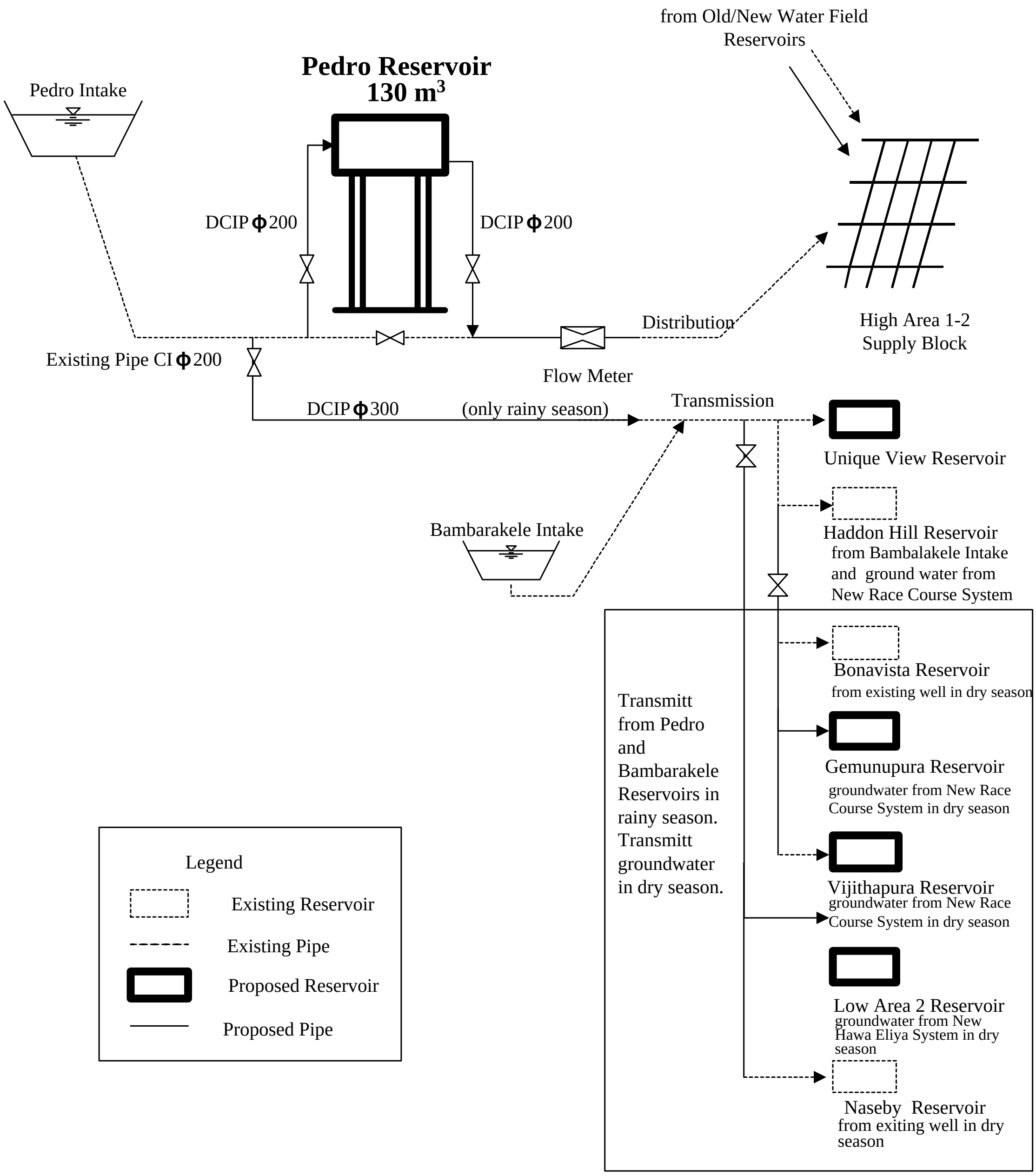


**Figure-2.19** **Unique View Reservoir**

- Receive surface water from Pedro and Bambarakele Intakes in rainy season and from Bambarakele intake in dry season
- Supply to Local Distribtuion in Unique View area
- Capacity of new reservoir is 190 $m^3$ to supply water 861$m^3$/day. New reservoir will be constructed adjacent to the existing reservoir of which capacity is 40 $m^3$

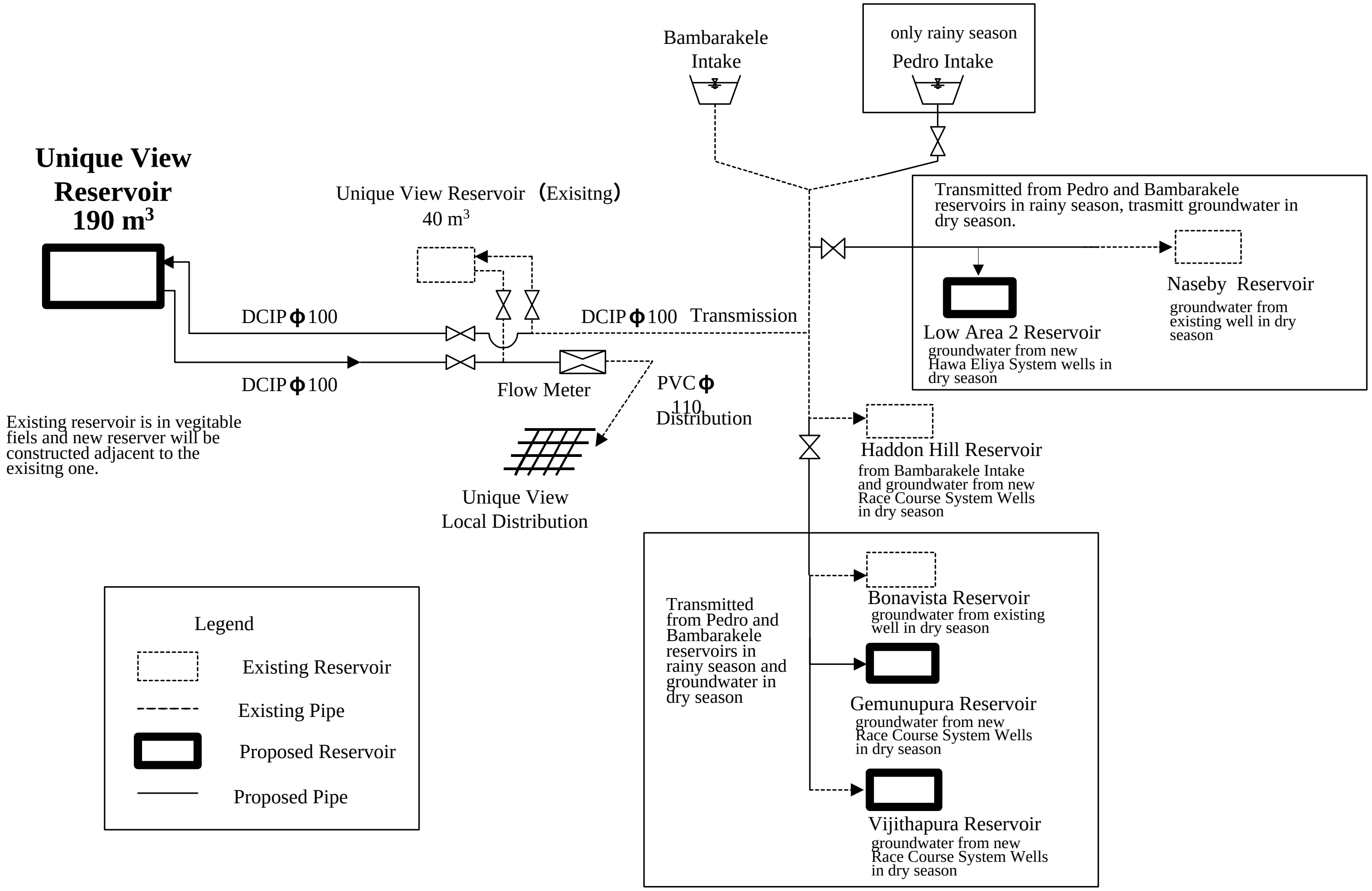


**Figure-2.20** **Gemunupura Reservoir**

- Receive surface water from Pedro and Bambarakele Intakes in rainy season. In dry season, receive groundwater from new Race Course System
- Supply water to Gemunupura Local Distribution and high part of Low Area 1
- Capacity of new reservoir is 40 $m^3$ to supply 143$m^3$/day

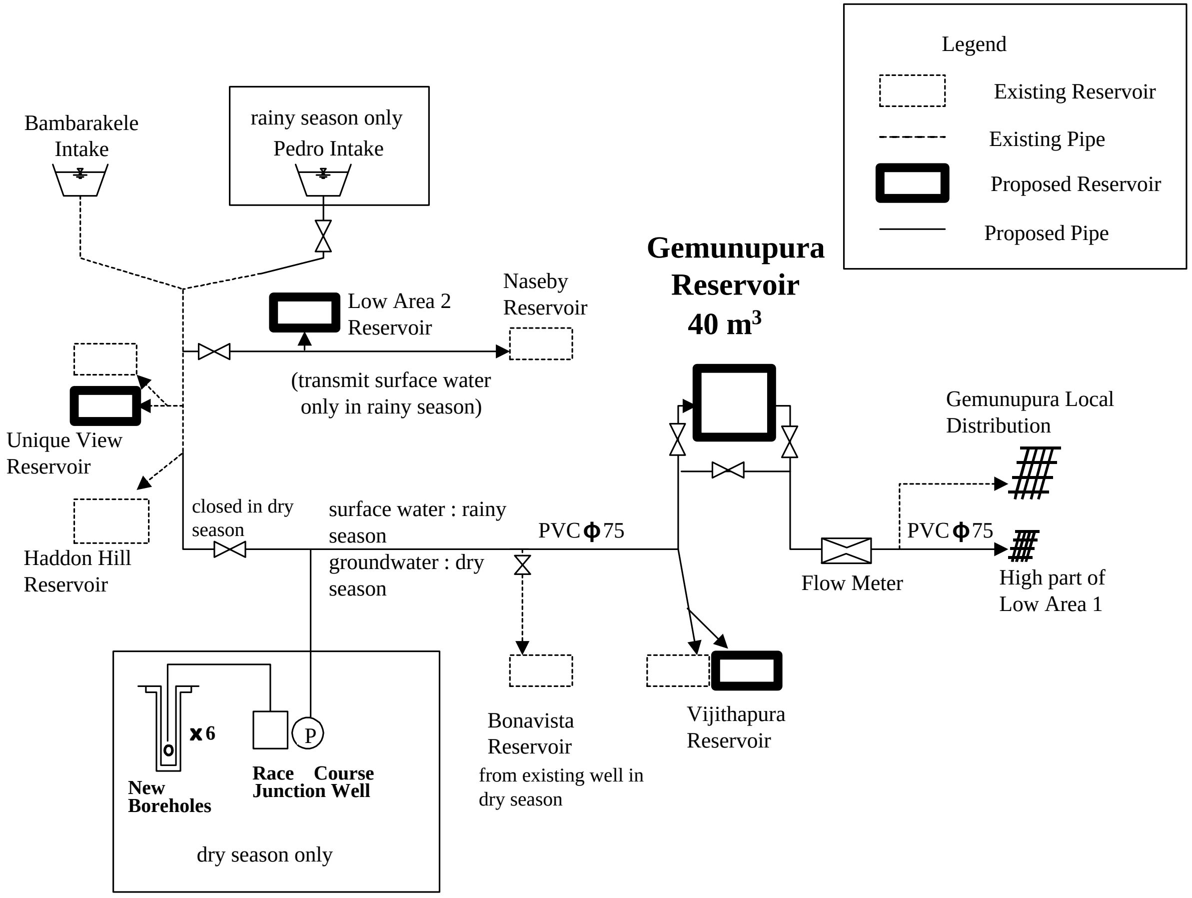


**Figure-2.21 Vijithapura Reservoir**

- Receive surface water from Pedro and Bambarakele Intakes in rainy season and groundwater from New Race Course system in dry season
- Supply water to Vijithapura Local Distribution
- Capacity of new reservoir is 110 $m^3$ to supply water 557$m^3$/day. New reservoir will be constructed adjacent to the existing reservoir of which capacity is 40 $m^3$.

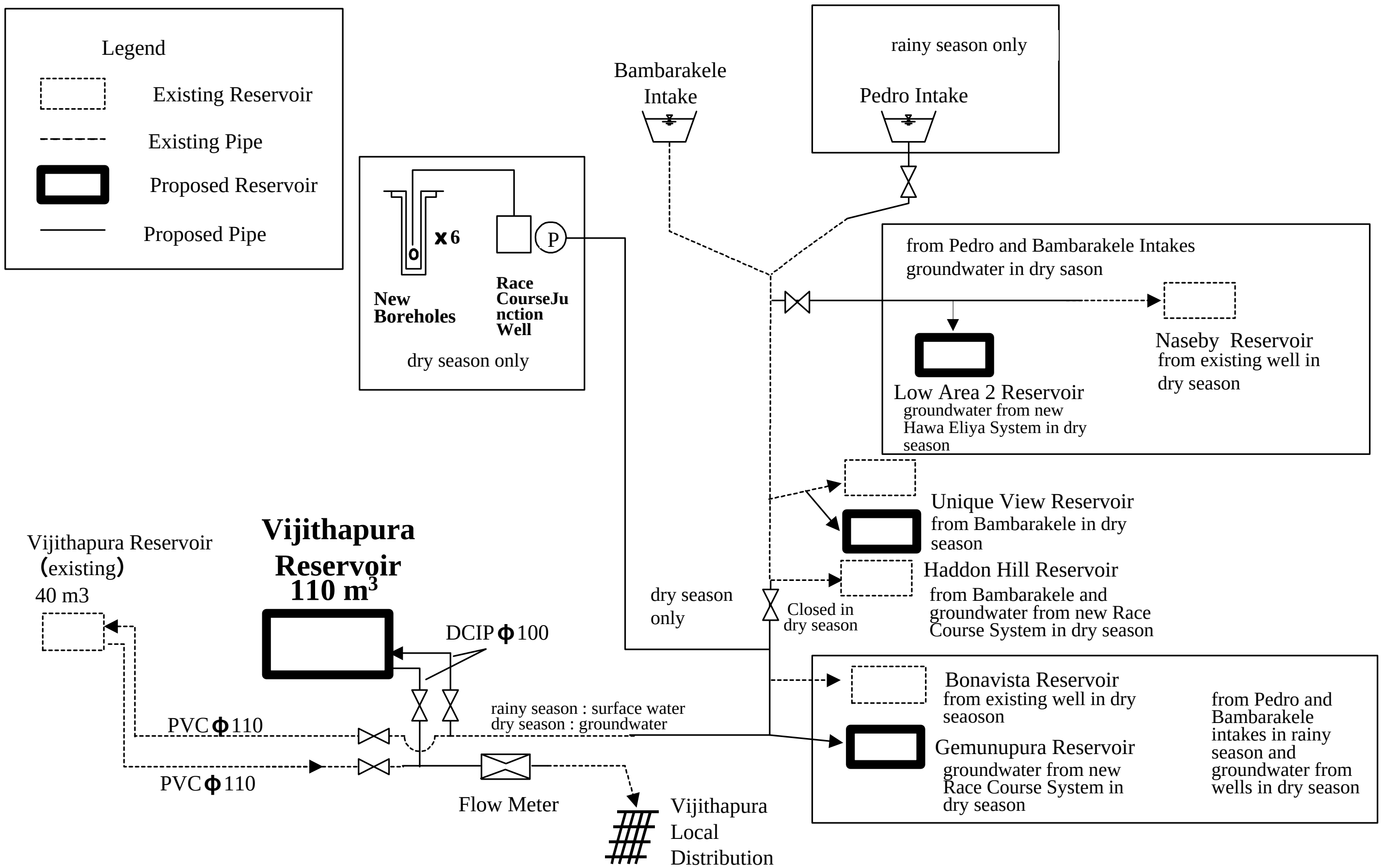
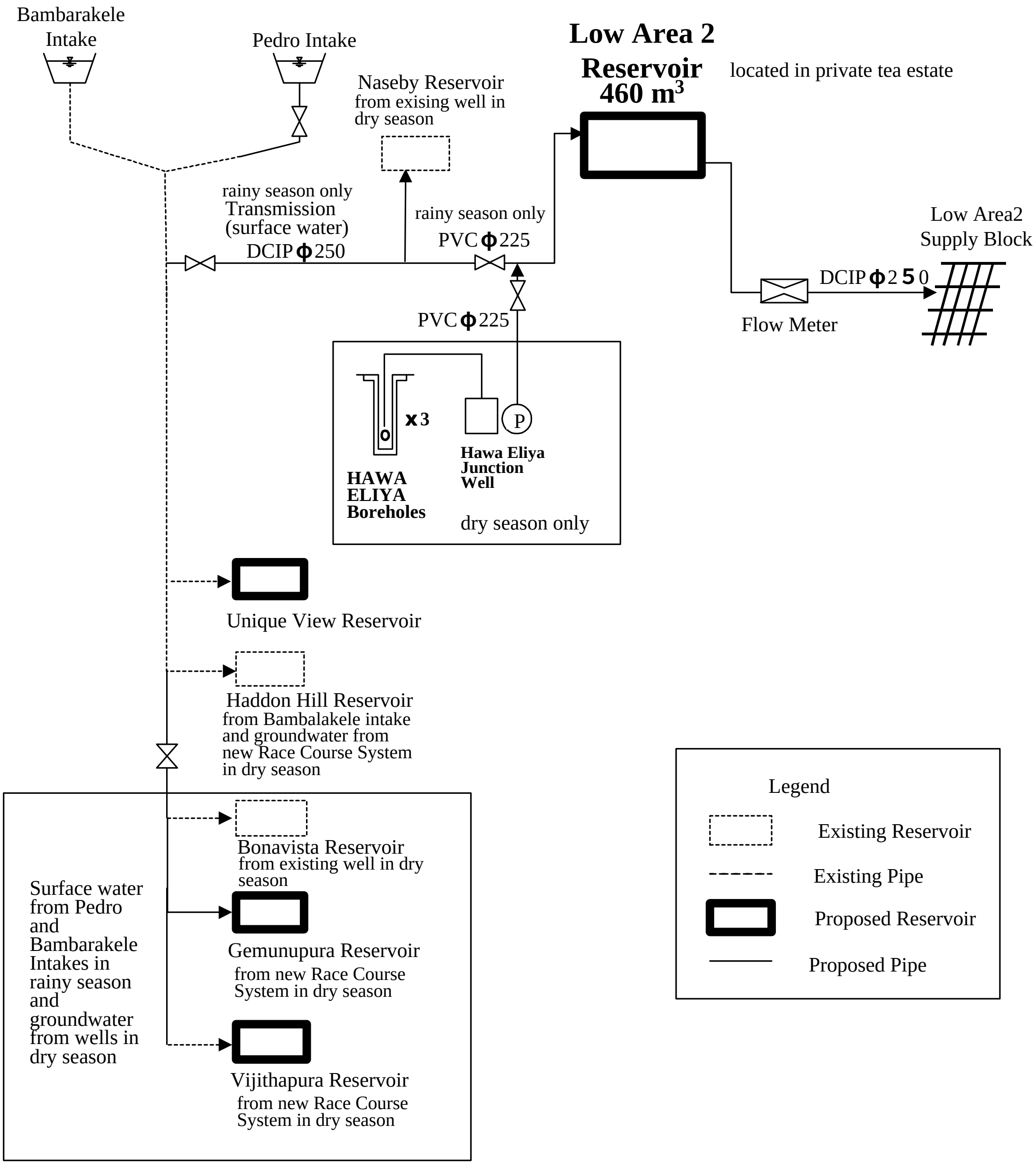


**Figure-2.22 Low Area 2 Reservoir**

- Receive surface water from Pedro and Bambarakele Intakes in rainy season and groundwater from new Hawa Eliya sysetm
- Supply to Low Area 2 Supply Block
- Capacity of new reservoir is 460 $m^3$ to supply water 1,743$m^3$/day



### 5) Disinfection Facility

Disinfection facilities were installed at all service reservoirs except Vijithapura and Unique View Service Reservoir by previous ADB Project. Although chlorine gas is used at Haddon Hill Service Reservoir, which has large capacity and good accessibility, calcium hypochlorite is used at the other service reservoirs. All of the disinfection facilities are kept in good condition but chlorine is not dosed properly at present. One of the reasons for improper chlorination is attributable to the fact that the shift and personnel in charge of regular maintenance for chlorine aid transportation and dissolution, in other words, individual role and responsibility are not clear. In order to resolve the situation, it is recommended to reorganize Waterworks structure to clearly identify the person in charge of each service reservoir and this reorganization is considered to lead appropriate operation including chlorination.

Six disinfection facilities in total are included in the scope of the project for each reservoir, which will be constructed under the project.

Chlorine gas, sodium hypochlorite and calcium hypochlorite are generally used for disinfection in water supply system. Among the above, calcium hypochlorite is selected as chlorine agent for the six new reservoirs considering size of service reservoirs, difficult accessibility to the sites, and usage of calcium hypochlorite at the existing reservoirs.

Drip-feeding method, same as the exiting chlorination method, is to be applied. It is planned to install chlorination facilities in a chlorine house on each service reservoir. A chlorine aide storage room will also be prepared in the chlorine house.

### 6) Distribution Facilities

#### a) Distribution Pipes

It is important to minimize the difference of water pressure in the service area in order to distribute water to consumer with adequate water pressure (elimination of low dynamic water pressure) and to reduce water leakage (prevention of high static water pressure). In order to keep reasonable water pressure, improvement of distribution network is planed by reinforcing new distribution pipes in addition to adequate separation of supply block. At first, pipes to be reinforced by 2015 are planed and then the ones to be required by 2005 are selected as the component of this project. Distribution system improvement is planned by carrying out hydraulic analysis of the network in rainy season and dry season of 2015 and 2005 in the same way as the previous JICA Study.

The locations of the existing and new distribution pipes are shown in **Figure-2.23**. Distribution Facility Location Map and the list of pipe length by pipe diameter for proposed distribution pipes are summarized in **Table-2.29**.

**Table-2.29**

**List of Proposed Distribution Pipes**

| Dia.(mm) | Material | Length(m) |
|---|---|---|
| 75 | PVC | 2,600 |
| 110 | PVC | 1,396 |
| 160 | PVC | 1,686 |
| 225 | PVC | 455 |
| 100 | DCIP | 100 |
| 250 | DCIP | 939 |
| | Total | 7,176 |

The areas with negative water pressure, existed in the previous JICA Study, are eliminated by reviewing supply block boundary, separation of transmission system from distribution system and reinforcement of distribution pipes.

**b) Selection of Pipe Material**

NWSDB are basically using imported DCIP pipes for diameter of 250 mm and larger and PVC pipes for less than 250 mm, which are produced in Sri Lanka. This selection is considered to be appropriate and therefore, the following pipe materials are used under this project.

Diameter 250 mm and more : Ductile Cast Iron Pipes (DCIP)

Diameter less than 250 mm : Polyvinyl Chloride Pipe (PVC)

DCIP is to be used for special pipe installation such as culvert/river crossing and piping on slope regardless of pipe diameter.

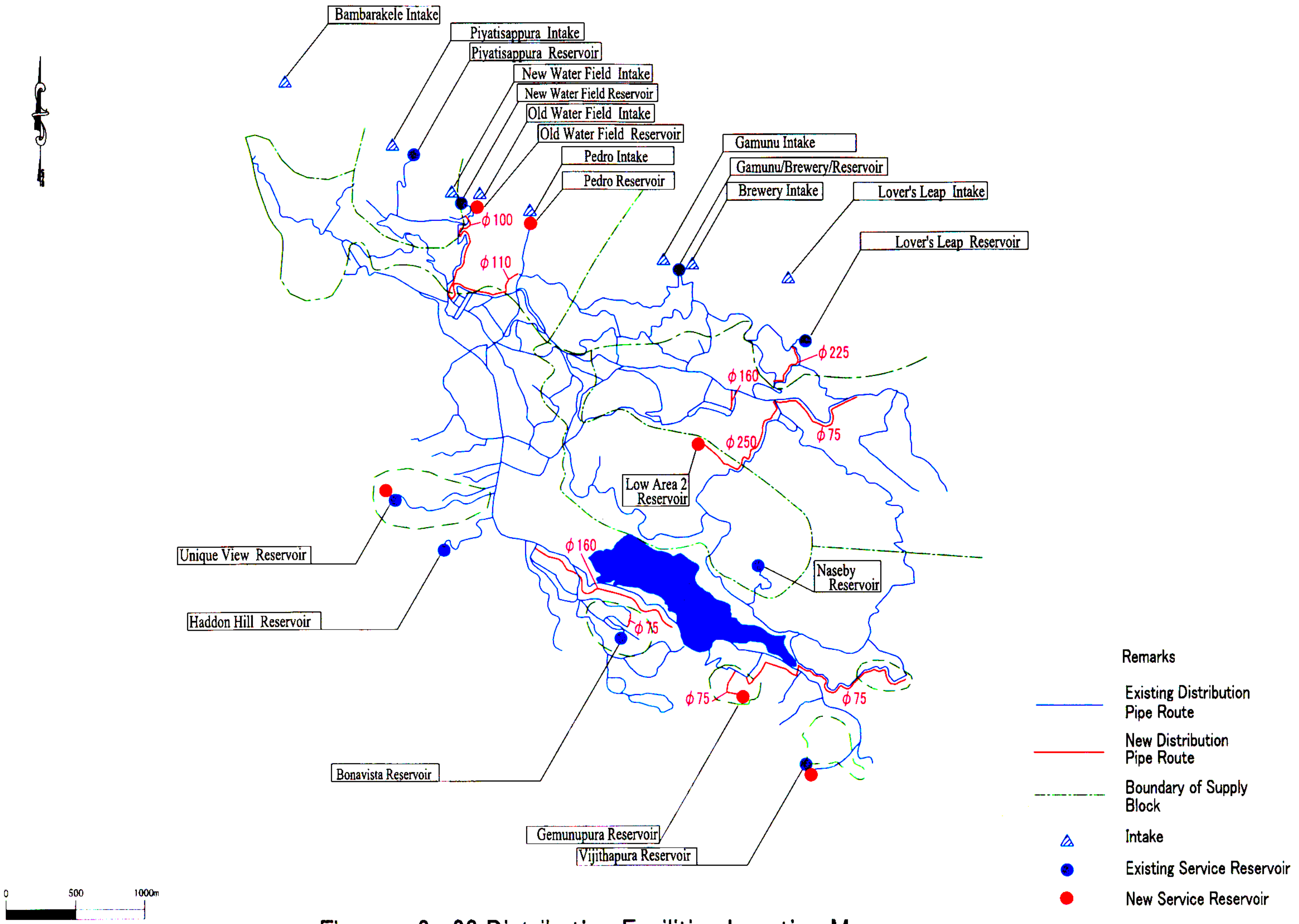



Figure – 2 . 23 Distribution Facilities Location Map

**c) Existing Valve Rehabilitation**

Some valves in the distribution system are not operable since they are buried under paved roads without surface valve covers and some valves are broken. Therefore, it takes time to stop water flow in pipes for repair and area of service suspension becomes wide. In order to carry out leakage reduction activities efficiently, it is planned to repair such existing valves as shown in **Table-2.30**.

**Table-2.30 List of Existing Valves to be Repaired**

| Pipe Diameter | Pipe Material | Location | Remarks |
|---|---|---|---|
| 100 | CIP | 3 | Installation of surface valve cover. |
| 150 | CIP | 3 | Installation of surface valve cover |
| 160 | PVC | 1 | Installation of surface valve cover |
| 225 | PVC | 3 | Installation of surface valve cover |
| 300 | CIP | 1 | Replacement of valve and installation of surface valve cover |

**Location of Valve Repair**

#### d) Alternate Pipe Route Suffering from Frequent Leakage

A existing distribution pipe route (CIP diameter 225 mm) near Lovers Leap Service Reservoir is suffering from frequent leakage because movement of land (chronic and very slow land slide at slope) causes pipe joints to loose. Nuwara Eliya Waterworks has repeated pipe repairs and those repairs cannot become drastic measures to stop occurrence of leakage. Therefore, this pipeline is planned to be laid detouring around the area of land movement and stop the usage of existing pipe. Water leakage due to such land movement is observed only in this location.

### 7) House Connection

The number of house connections is 4,335 as of September 2000 and in the year 2005 the number of house connections will increase to 5,200. About 900 house connections are assumed to be increased. For new connections, consumer should pay connection fee of Rs. 4,500 and this amount is used by the Waterworks for purchasing of required materials and for installation work of new connections. The material cost is Rs. 2,760 in total including Rs. 1,850 is for water meter. The connection fee of Rs. 4,500 can cover the installation costs, therefore, special budget will not be required for installation of new connections under this Project.

Considering the above this project does not include costs for materials and installation of new connections increased by the target year.

## 2-2-2-3 Equipment Plan

### 1) Well Pump

In dry season, to substitute surface water shortage, groundwater will be supplied. Type of well pump will be submergible type since it has flexibility against groundwater level fluctuation and the least costs. Numbers of pumps required are shown on **Table-2.31** with their specifications.

**Table-2.31 List of Well Pumps**

| Wells | Specifications | Number of Pumps |
|---|---|---|
| Race Course System (from Hawa Eliya) | 0.56 $m^3$/m x 55 m x 11 KW x 3000 rpm<br>0.56 $m^3$/m x 50 m x 11 KW x 3000 rpm | 1 unit<br>1 unit |
| Race Course System (from Golf Course) | 0.56 $m^3$/m x 30 m x 5.5 KW x 3000 rpm | 4 units |
| Hawa Eliya System (from Hawa Eliya) | 0.56 $m^3$/m x 30 m x 5.5 KW x 3000 rpm | 3 units |

Well submergible pumps are most important equipment among the water supply system which abstract groundwater and transmit to junctions well. The pumps shall be reliable ones which are strong enough for continuous operation and easy operation and maintenance. In the case the pump quality is not reliable, it will require many spare parts to fix frequent breakdown and it will cause suspend of water supply and increase operation and maintenance costs. From these points of view, it is recommended to use Japanese made submergible pumps which have high reliability.

### 2) Transmission Pump

Transmitted groundwater to the respective junction wells, Low Areas 1 and 2, water will be transmitted to service reservoirs. At the Low Area 1 pump station, transmission pumps to Haddon Hill Reservoir via transmission pipeline which will be used in rainy season and pumps to Gemunupura and Vijithapura Reservoirs will be accommodated. At the Low Area 2 pump station, pumps for Low Area 2 Reservoir will be installed. Type of pumps will be horizontal volute pump. Number of pumps and their specifications are shown on **Table-2.32**.

**Table-2.32 List of Transmission Pump**

| Transmission Pump | Specifications | Number of Pumps |
|---|---|---|
| Haddon Hill | 2.74 $m^3$/m x 60 m x 55 KW x 1500 rpm | 2 units（Operation : 1, Standby : 1) |
| Gemunupura/Vijithapura | 0.49 $m^3$/m x 75 m x 15 KW x 1500 rpm | 2 units（Operation : 1, Standby : 1) |
| Low Area 2 | 1.21 $m^3$/m x 80 m x 45 KW x 1500 rpm | 2 units（Operation : 1, Standby : 1） |

Transmission pumps as well as well submergible pumps described above shall be reliable for the long-term continuous operation and easy operation and maintenance. Unreliable pump will require more spare parts and consume time for repair work. Frequent repair and many spare parts will increase maintenance costs. From these points, pump should be selected among satisfactory quality and non-defective products.

Taking into consideration the situations of electricity at the site such as big voltage fluctuation, etc., it is recommended to adopt higher grade of insulation class for the electrical motors of the transmission pumps than that of the standard products. Although the insulation class of the standard products is normally E class, it is to be studied to adopt B class or higher. Furthermore, in case the power failure occurs more frequently, it should be also studied to take measures against overheating by equipping thermo switches to the motors, as the motors may suffer from overheating and, finally, burning due to repeated starting and stopping. Because of these situations, the transmission pumps shall be also Japanese products, as they possess higher reliability and more excellent quality.

**3) Booster Pump**

In rainy season, surface water will be supplied by gravity system as much as possible. However, for the remote area and high elevation area, booster pumps will be used for water transmission. Booster pumps will be required to Unique View, Naseby, and Gemunupura where is newly included in service area, reservoirs. Since transmission and distribution pipes are separated, a booster pump for Vijithapura reservoir is not required although this booster pump was planned under the previous JICA Study.

In dry season, these booster pumps for Naseby and Gemunupura Reservoirs will not be used and only booster pump for Unique View Reservoir will be used. Type of pumps will be horizontal volute pump. List of the booster pumps are shown **Table-2.33**.

**Table-2.33 List of Booster Pump**

| Booster Pump | Specifications | Number of Pumps |
|---|---|---|
| Unique View | 0.60 $m^3$/m x 75 m x 15 KW x 3000 rpm | 2 units（Operation : 1, Standby : 1) |
| Gemunupura | 0.10 $m^3$/m x 25 m x 2.2 KW x 1500 rpm | 2 units（Operation : 1, Standby : 1) |
| Naseby | 0.39 $m^3$/m x 25 m x 3.7 KW x 3000 rpm | 2 units（Operation : 1, Standby : 1） |

To utilize residual pressure upstream of the booster pump, the pump will be directly connected to the pipeline without exposure. Pumps for Unique View Reservoir will be equipped with flywheel, which has $GD^2$ : 1kgf-$m^2$to, avoid surging when pump is stopped. From these points of view, it is recommended to use Japanese made pumps, which have high reliability.

**4) Power Control Panel**

As for the power control panel for the pumps delivered in this work, the following countermeasures are required to be considered during the planning and design stages due to the situations of the electricity at the site:

1) There shall be equipped a relay to shut down the power supply in case the voltage fluctuates beyond the allowable voltage fluctuation amplitude, as the voltage fluctuation of the power source is big.
2) There shall be equipped relays of open phase and reversed phase, as the countermeasures against open phase and reversed phase of the power source.
3) There shall be equipped a relay of instantaneous electrical power failure as the countermeasures during instantaneous power failure due to lightning, etc., in order to maintain the state before the power failure.
4) There shall be equipped a condenser for power factor improvement, in order to reduce the power consumption.
5) There shall be adopted the power distribution method, in order to correspond to the local electricity system, as the 3 phase 4 wire system is adopted at the site, which is different from the 3 phase 3 wire system in Japan.
6) There shall be adopted the control appliances, in order to correspond to the control circuit voltage at the site, as the voltage for control is 230V or 240V there.
7) There shall be equipped the appliances for power receiving (such as circuit breakers, voltmeters, ammeters, watt-hour meters, lightning arresters, etc. on the panels, in order to manage the power source supplied from the power company.
8) There shall be adopted a method to suppress the starting current of the pumps of large capacity, especially by studying the torque, etc. to be used.

Accordingly, there shall be adopted the products made in Japan with higher reliability from the viewpoints of both design and quality, as the electrical products with higher reliability are available in Japan, which can correspond to the above-mentioned countermeasures.

**5) Water Meter and Meter Test Bench**

At present, there are approximately 800 defective water meters, about 18 % of water meters and while other meters are running, meter calibration has not been implemented. To contribute reduction of unaccounted-for water, new 800 water meters will be supplied for replacement. Supply of meter test bench for calibration of water meter will also be included in the scope of project.

Waterworks of Nuwara Eliya shall carry out the work for replacement of water meters. Meter calibration using the meter test bench will require training. Staff of Nuwara Eliya Waterworks is possible to have training at Colombo Waterworks which has the meter test bench.

**6) Method of Installation**

**a) Transportation of Equipment to Site**

Equipment to be installed will be transported to the site from stockyard or warehouse by truck or by manpower depend on the site accessibility.

**b) Procedure of Installation**

At the installation site, close supervision by Japanese specialist will be required for securing quality, schedule control, and safety protection. Procedure will be as follows.

**Confirmation of Structure Dimension**

Before installation of the equipment, dimensions of structure shall be confirmed and if there is an error at the location of installation, the error shall be remedied before the installation work.

**Preparation of Base**

Base of equipment shall be prepared by reinforced concrete.

**Installation of Equipment**

i) Pump

At the first step, pump shall be temporarily installed and horizontal axis shall be adjusted using level and vertical axis shall be adjusted at the flange surfaces, which are processed mechanically. Secondly, pump base elevation shall be measured from the elevation of inlet and outlet of the pump. Tuning of pump location shall be conducted by confirmation of centerline of inlet and outlet pipe and relation with pump house structure. Centering of pump shall be confirmed by dial gage.

ii) Tank

After temporary installation, horizontal axis shall be confirmed by level and base bolts shall be tightened.

iii) Panel

After temporary installation, horizontal axis shall be confirmed by level and fixed.

**Inspection of Installation**

After installation of equipment, horizontal line, vertical line, and centering shall be confirmed.

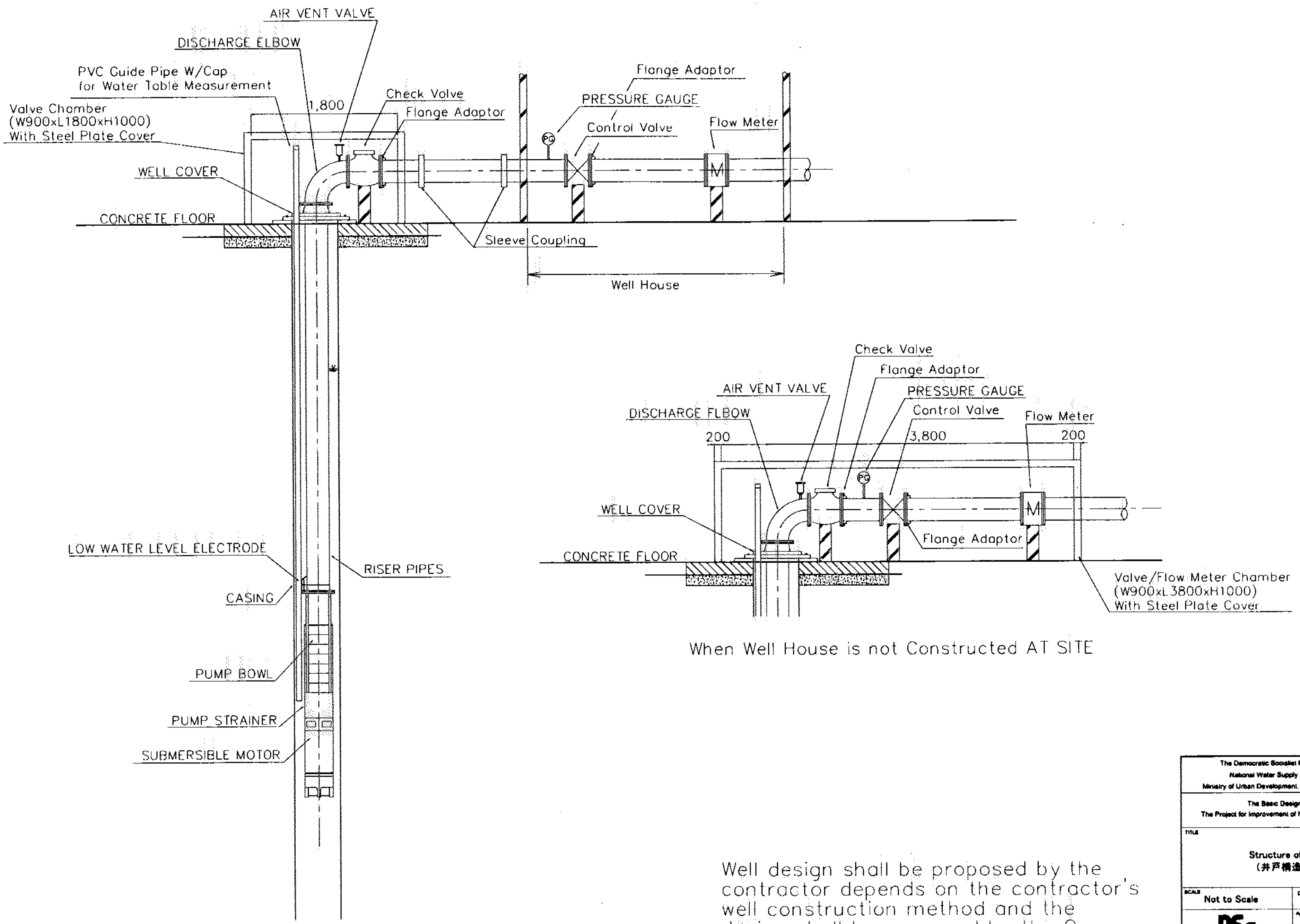
**c) Test Operation**

After inspection of installation, test operation shall be conducted. In the case of pump equipment, direction of rotation, current and voltage shall be checked.

### 2-2-3 Basic Design Drawings

Structures of major facilities are shown on drawings as listed below.

List of Drawings :




When Well House is not Constructed AT SITE

Well design shall be proposed by the contractor depends on the contractor's well construction method and the design shall be approved by the Owner.

| | |
|---|---|
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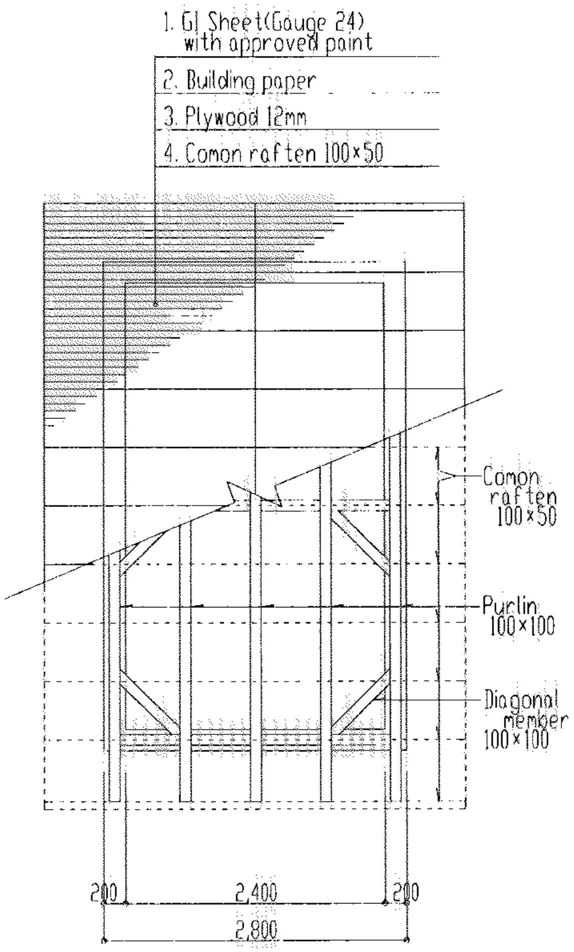
| The Basic Design Study on<br>The Project for Improvement of Nuwara Eliya Water Supply | |
| TITLE<br>Structure of Well<br>(井戸構造図) | |
| SCALE Not to Scale | DRAWING NO. Figure-2.24 |
| NSC<br>NIHON SUIDO<br>CONSULTANTS CO., LTD.<br>TOKYO-JAPAN | Approved By / Date<br>Designed By / Date |

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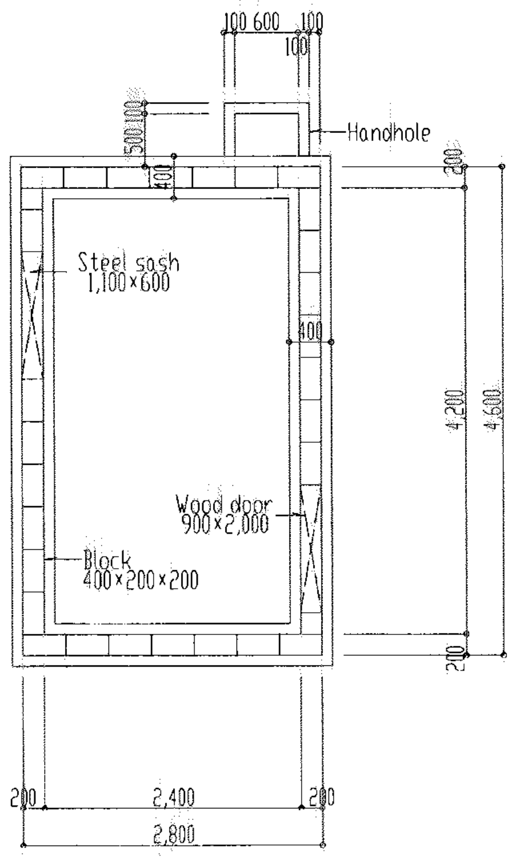
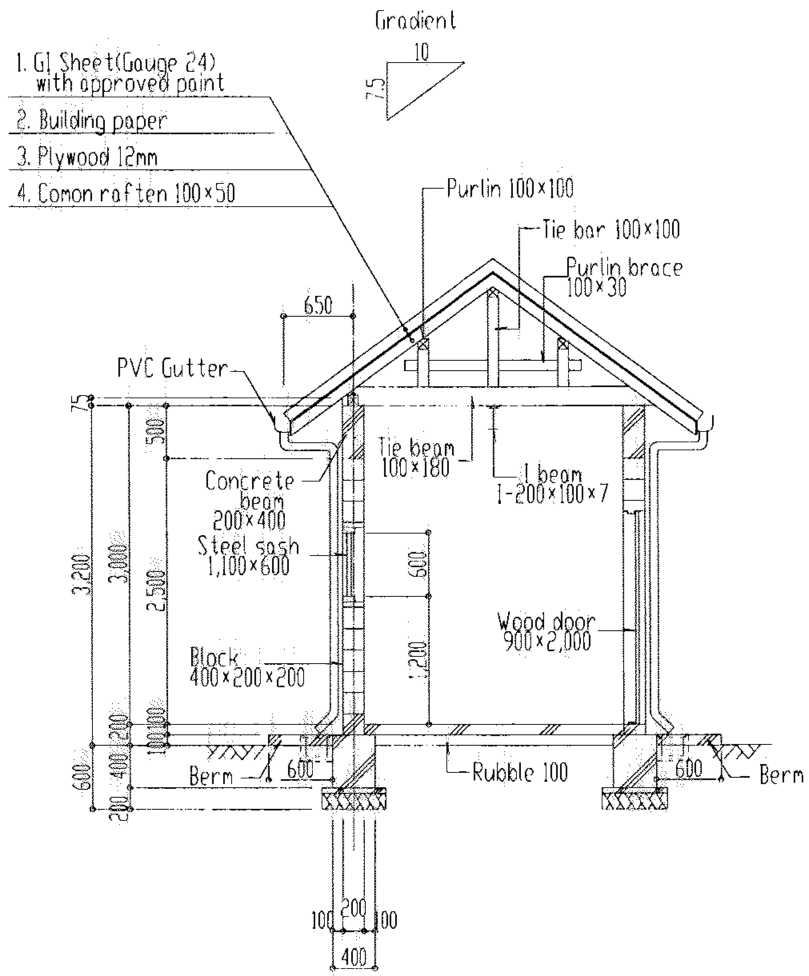



PLAN




SECTION

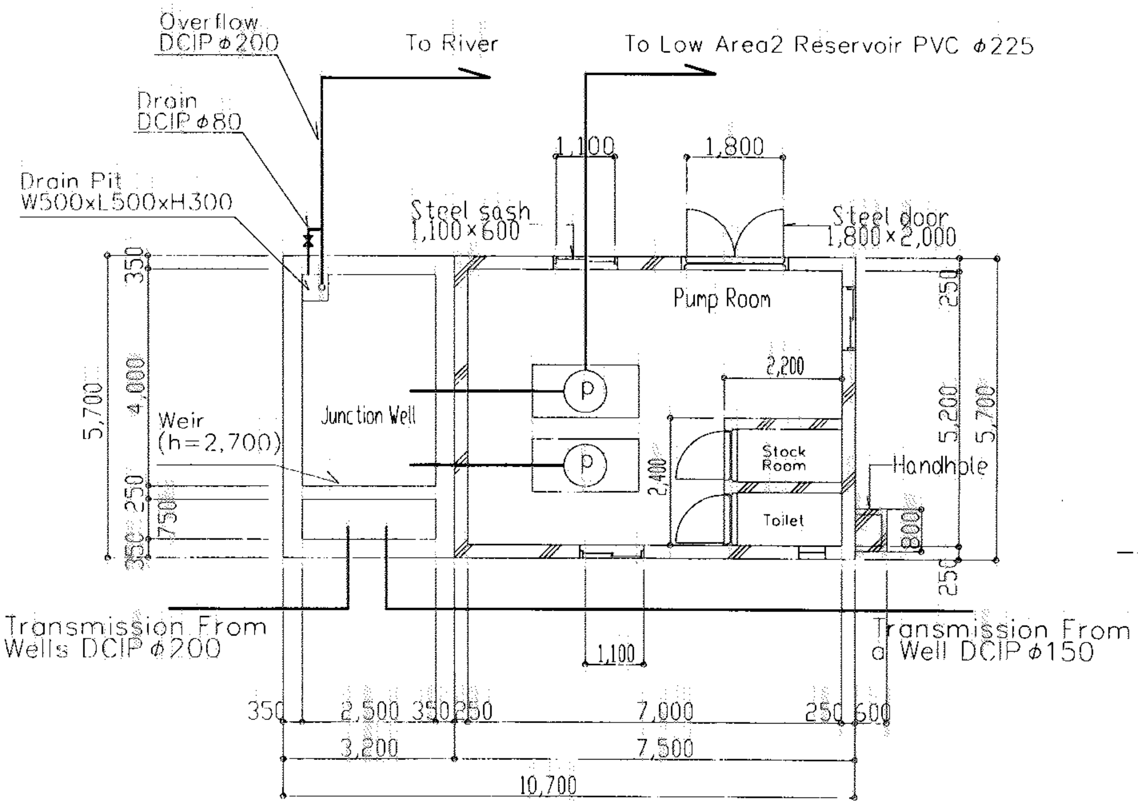
The Democratic Socialist Republic of Sri Lanka
National Water Supply & Drainage Board
Ministry of Urban Development, Housing and Construction

The Basic Design Study on
The Project for Improvement of Nuwara Eliya Water Supply

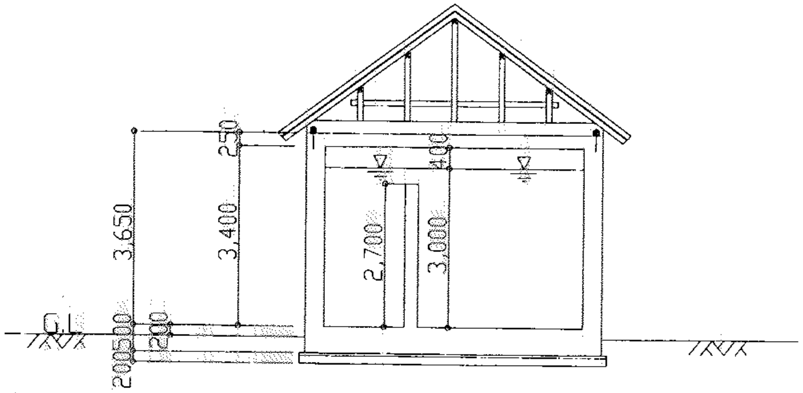
TITLE

Well Pump House
（井戸ポンプ棟）

| SCALE PLAN 1/50 | DRAWING NO Figure - 2.25 |
|---|---|
| NSC NIHON SUIDO CONSULTANTS CO., LTD. TOKYO-JAPAN | Approved By / Date<br>Designed By / Date |




PLAN




SECTION

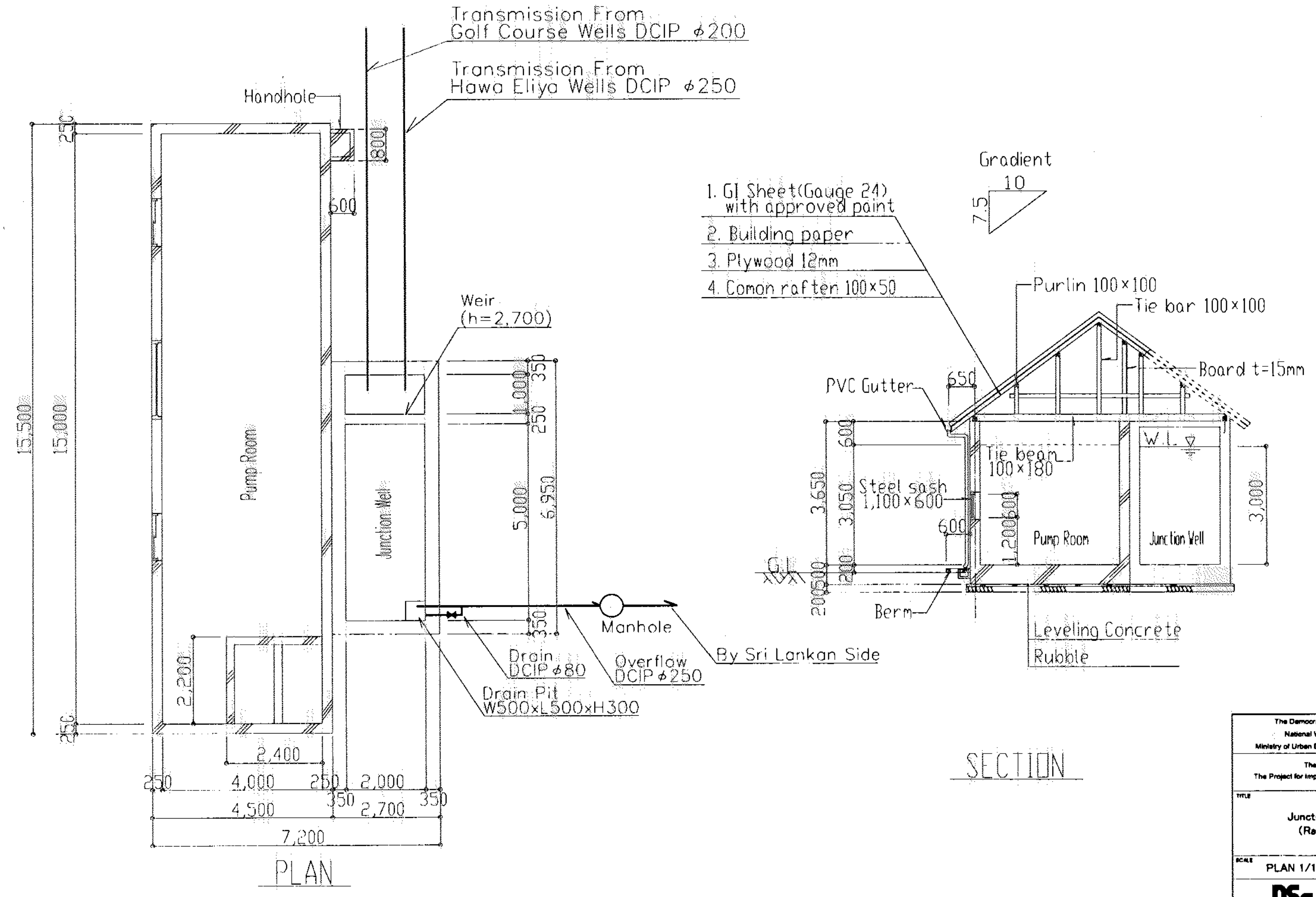
The Democratic Socialist Republic of Sri Lanka
National Water Supply & Drainage Board
Ministry of Urban Development, Housing and Construction

The Basic Design Study on
The Project for Improvement of Nuwara Eliya Water Supply

TITLE

Hawa Eliya Junction Well &
Pump House Structure
（ハワエリア接合井・ポンプ室構造図）

| SCALE PLAN 1/100 | DRAWING NO. Figure-2.26 |
|---|---|
| NIHON SUIDO CONSULTANTS CO., LTD TOKYO-JAPAN | Approved By / Date<br>Designed By / Date |

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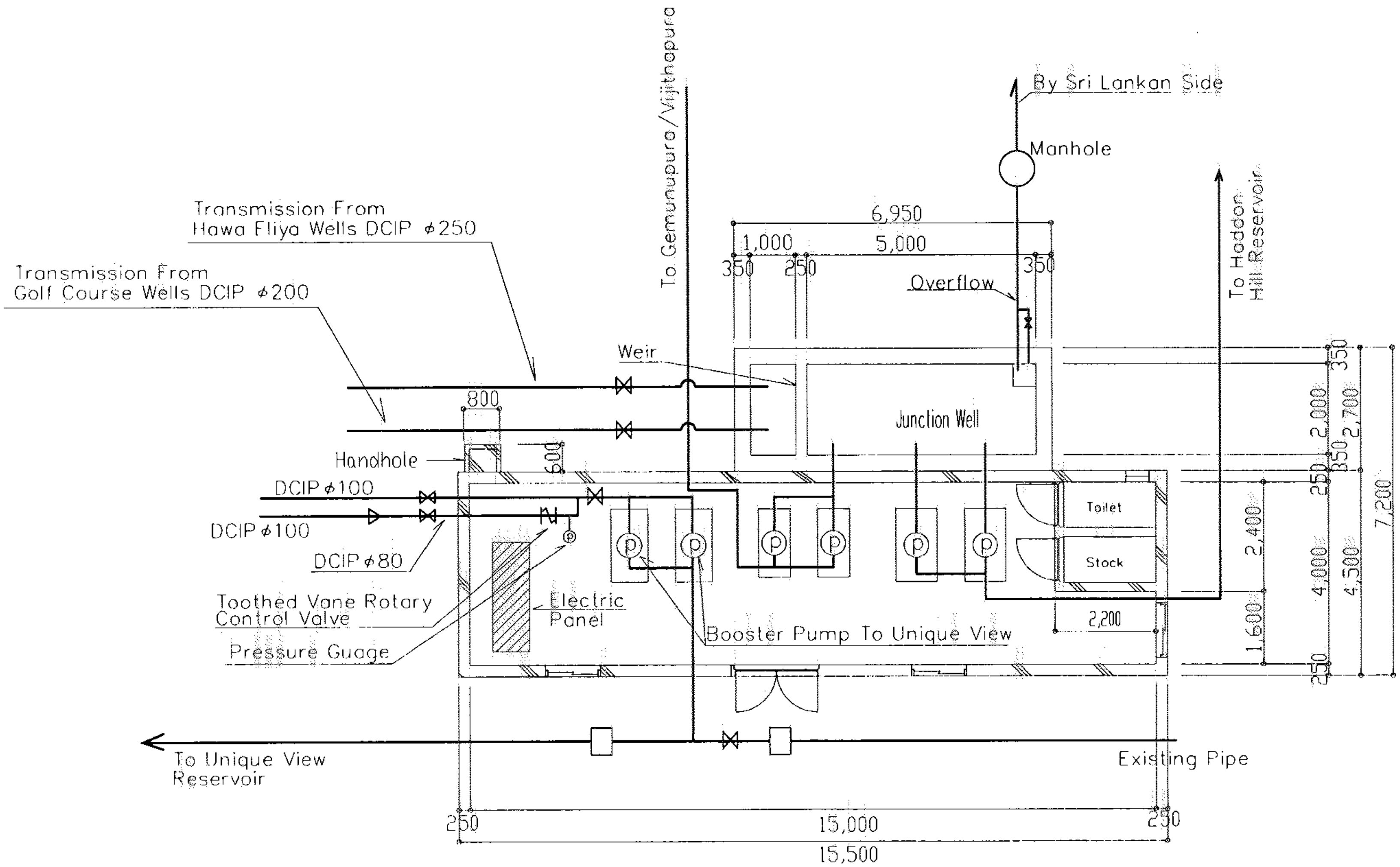
TITLE
Junction Well (Race Course)
(Race Course 接合井)

SCALE PLAN 1/100 | DRAWING NO Figure – 2.27

Approved By | Date

Designed By | Date

NIHON SUIDO CONSULTANTS CO., LTD. TOKYO-JAPAN

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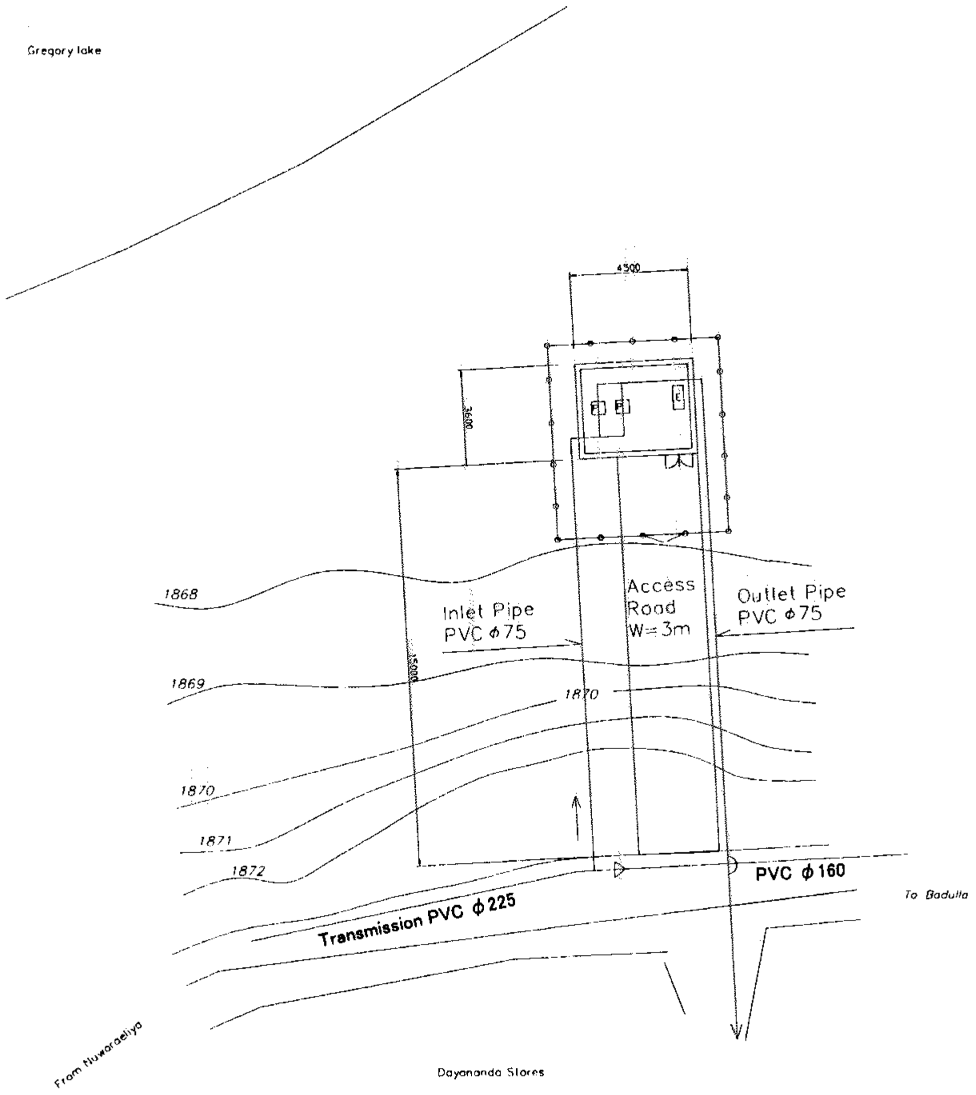
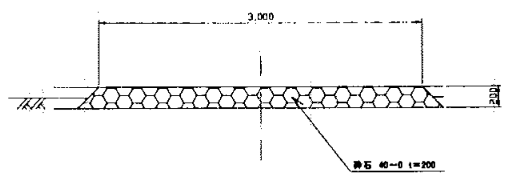
TITLE
Race Course Junction Well &
Pump House Structure-1
(レースコース接合井・ポンプ室構造図 -1)

| SCALE | DRAWING NO |
|---|---|
| PLAN 1/100 | Figure - 2.28 |
| NIHON SUIDO CONSULTANTS CO., LTD. TOKYO-JAPAN | Approved By / Date<br>Designed By / Date |

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The Basic Design Study on
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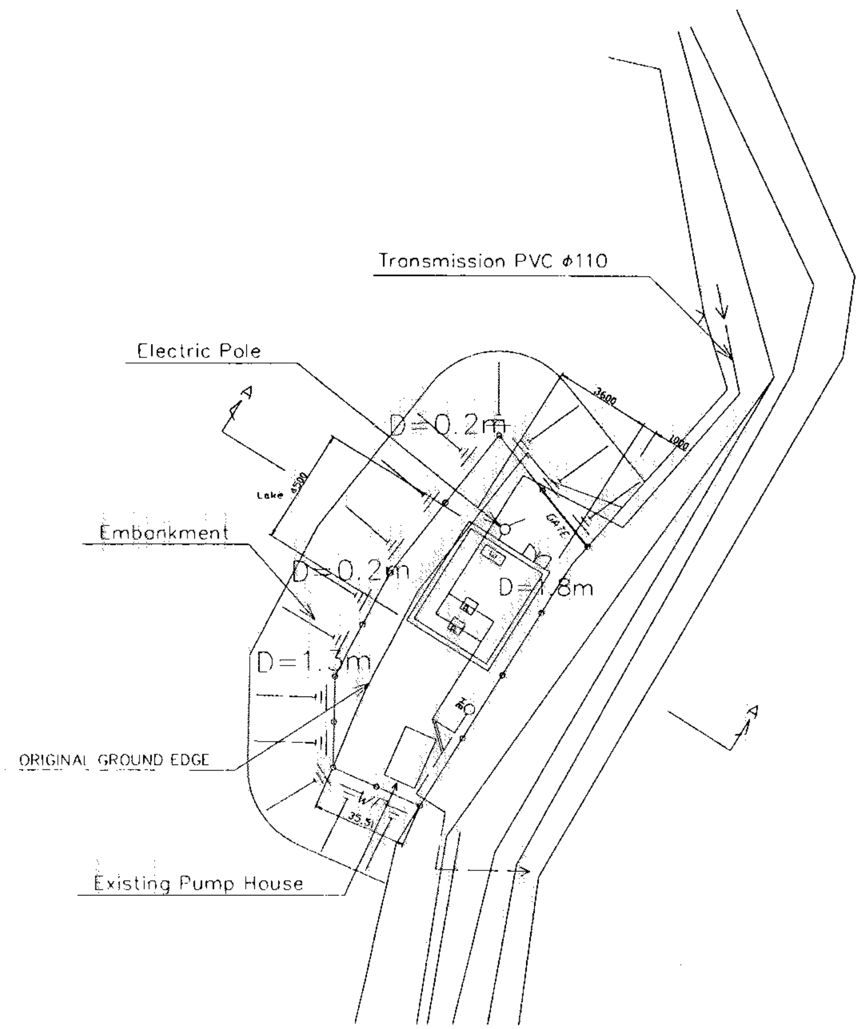
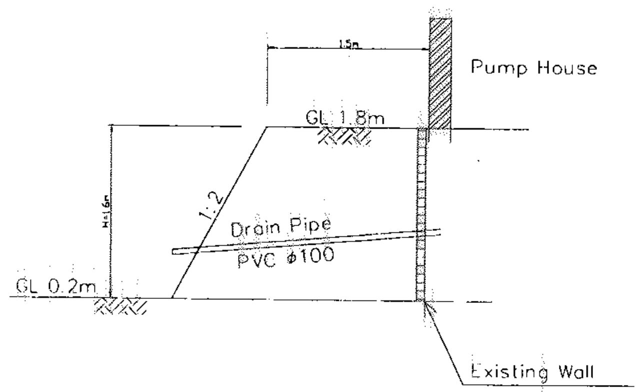
TITLE

Transmission Booster Pump House
(送水増圧ポンプ棟 Gemunupura)

| SCALE | DRAWING NO |
|---|---|
| 1/200 | Figure-2. 29 |
| NIHON SUIDO CONSULTANTS CO., LTD. TOKYO-JAPAN | Approved By / Date<br>Designed By / Date |




Embankment Section A-A
S=1/50

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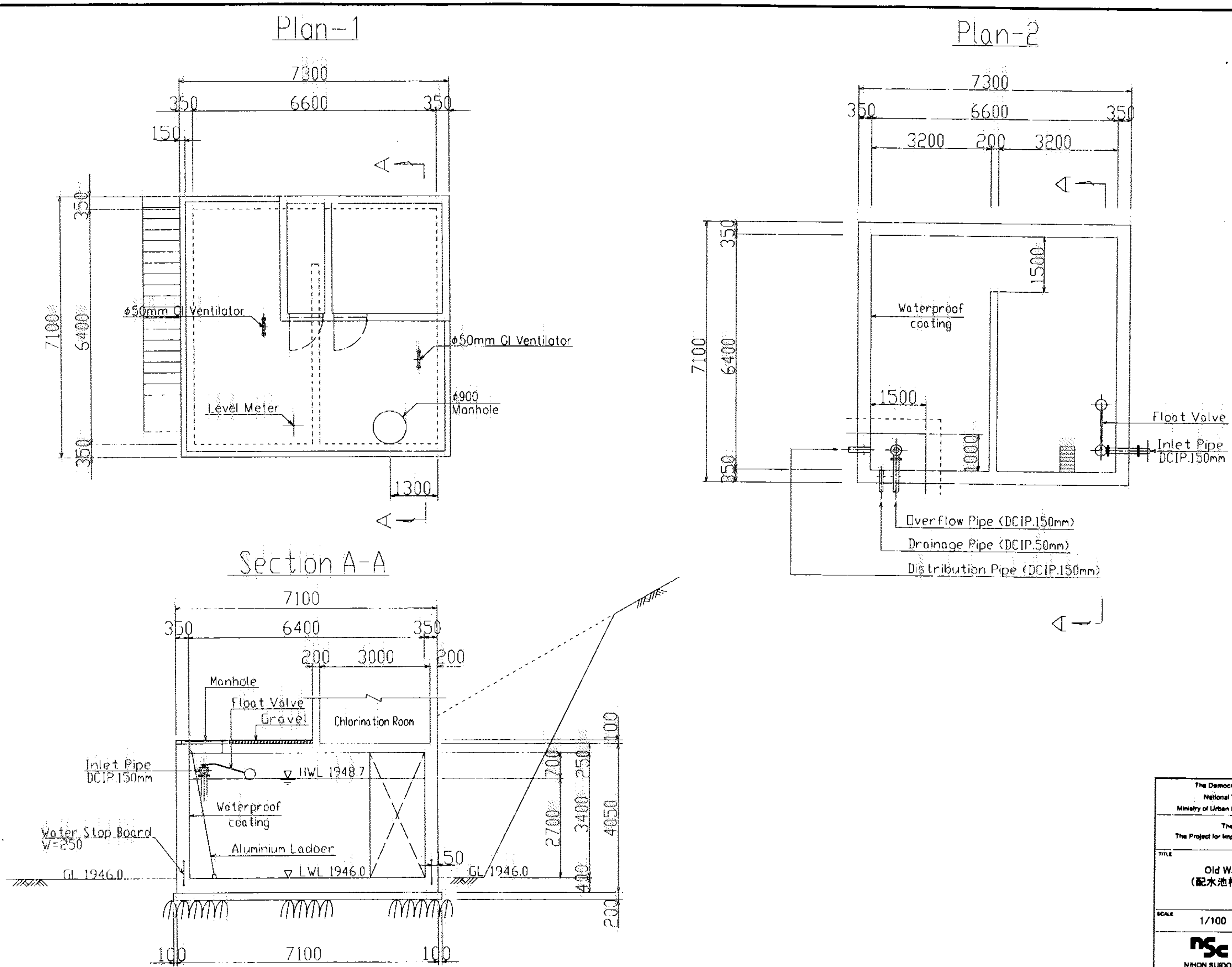
| The Democratic Socialist Republic of Sri Lanka<br>National Water Supply & Drainage Board<br>Ministry of Urban Development, Housing and Construction | |
| The Basic Design Study on<br>The Project for Improvement of Nuwara Eliya Water Supply | |
| TITLE<br>Transmission Booster Pump House<br>(送水増圧ポンプ棟 Naseby) | |
| SCALE 1/200 | DRAWING NO Figure-2.30 |
| NIHON SUIDO<br>CONSULTANTS CO., LTD.<br>TOKYO-JAPAN | Approved By / Date<br>Designed By / Date |

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Ministry of Urban Development, Housing and Construction

The Basic Design Study on
The Project for Improvement of Nuwara Eliya Water Supply

TITLE
Old Water Field Reservoir
(配水池構造図 Old Water Field
Capacity : 110m3)

| | | |
|---|---|---|
| SCALE 1/100 | DRAWING NO Figure-2.31 | |
| NIHON SUIDO CONSULTANTS CO., LTD. TOKYO JAPAN | Approved By | Date |
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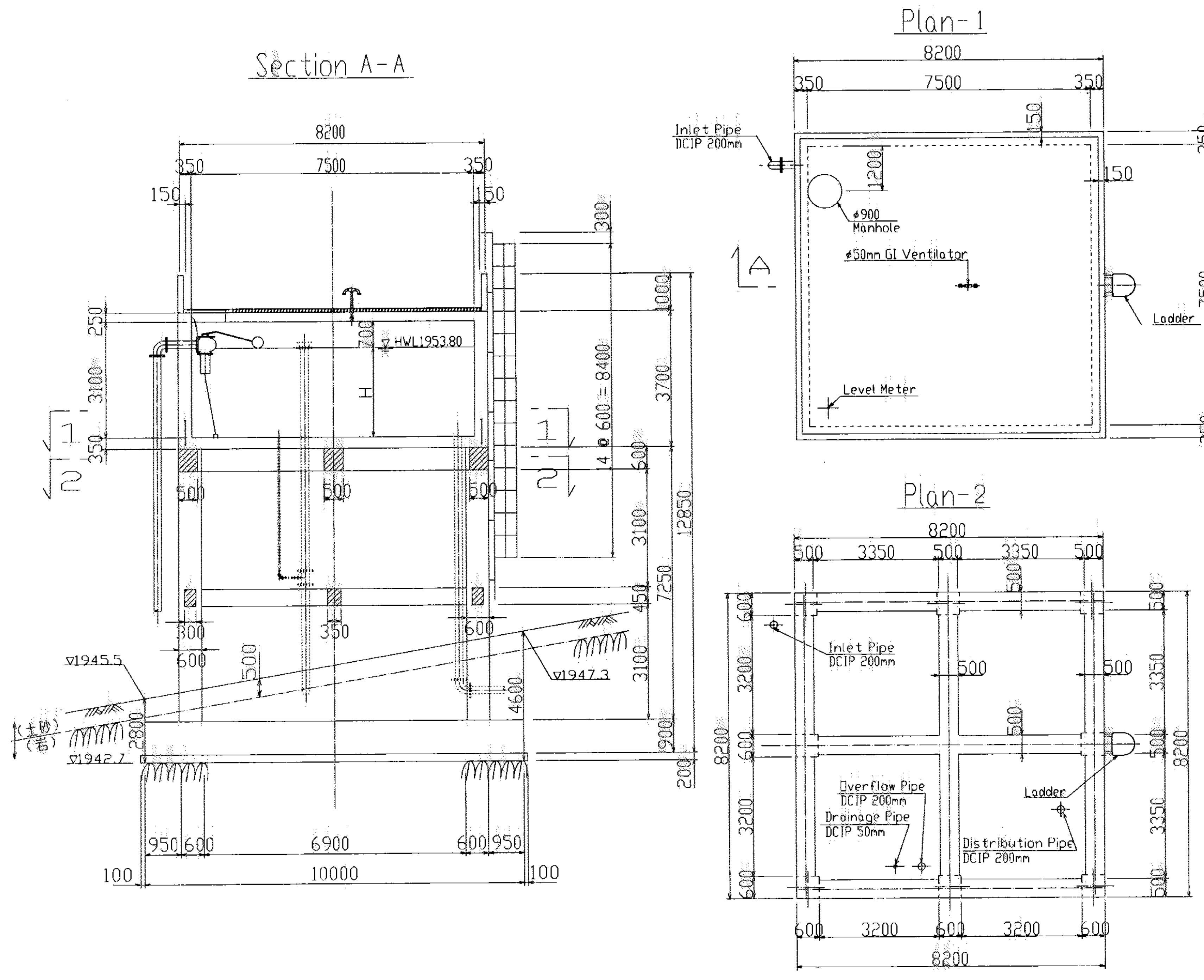


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Ministry of Urban Development, Housing and Construction

The Basic Design Study on
The Project for Improvement of Nuwara Eliya Water Supply

TITLE
Pedro Reservoir
(配水池構造図 Pedro Capacity : 130m3)

| SCALE | DRAWING NO. |
|---|---|
| 1/100 | Figure-2.32 |

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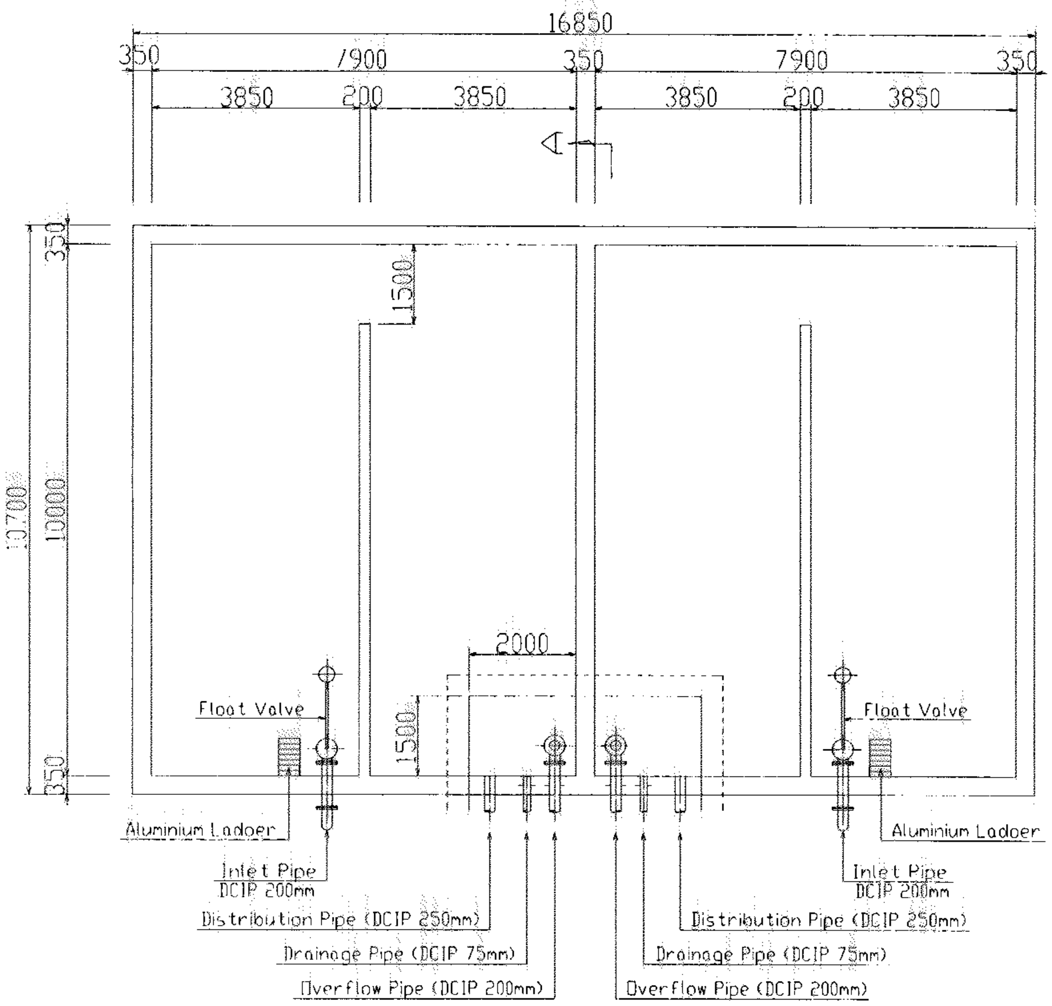
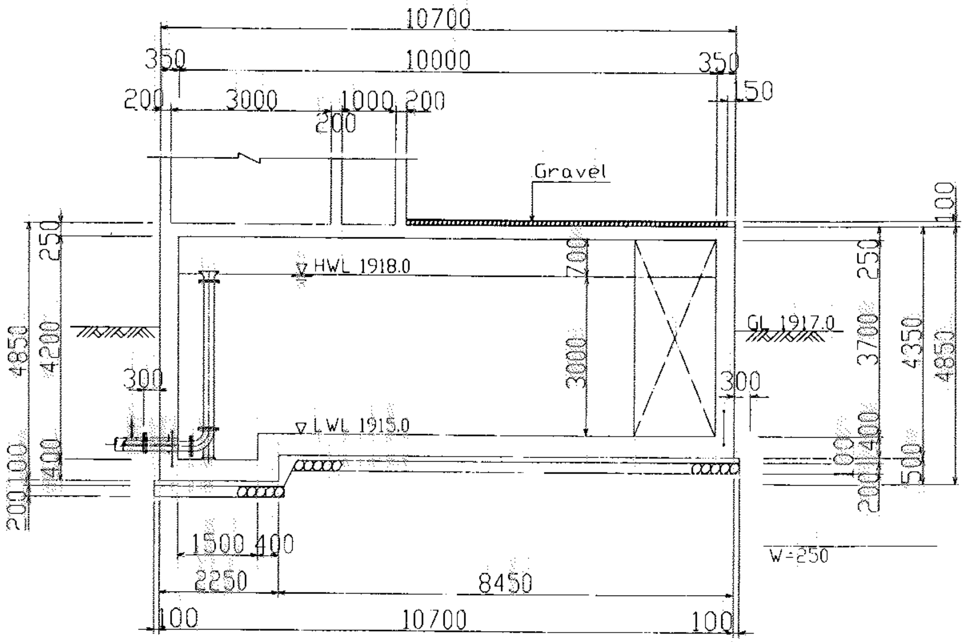
# Plan-2




# Section A-A

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The Basic Design Study on
The Project for Improvement of Nuwara Eliya Water Supply

TITLE
Low Area2 Reservoir
(配水池構造図 Low Area2 Capacity : 460m3)

| SCALE 1/100 | DRAWING NO. Figure-2.33 |
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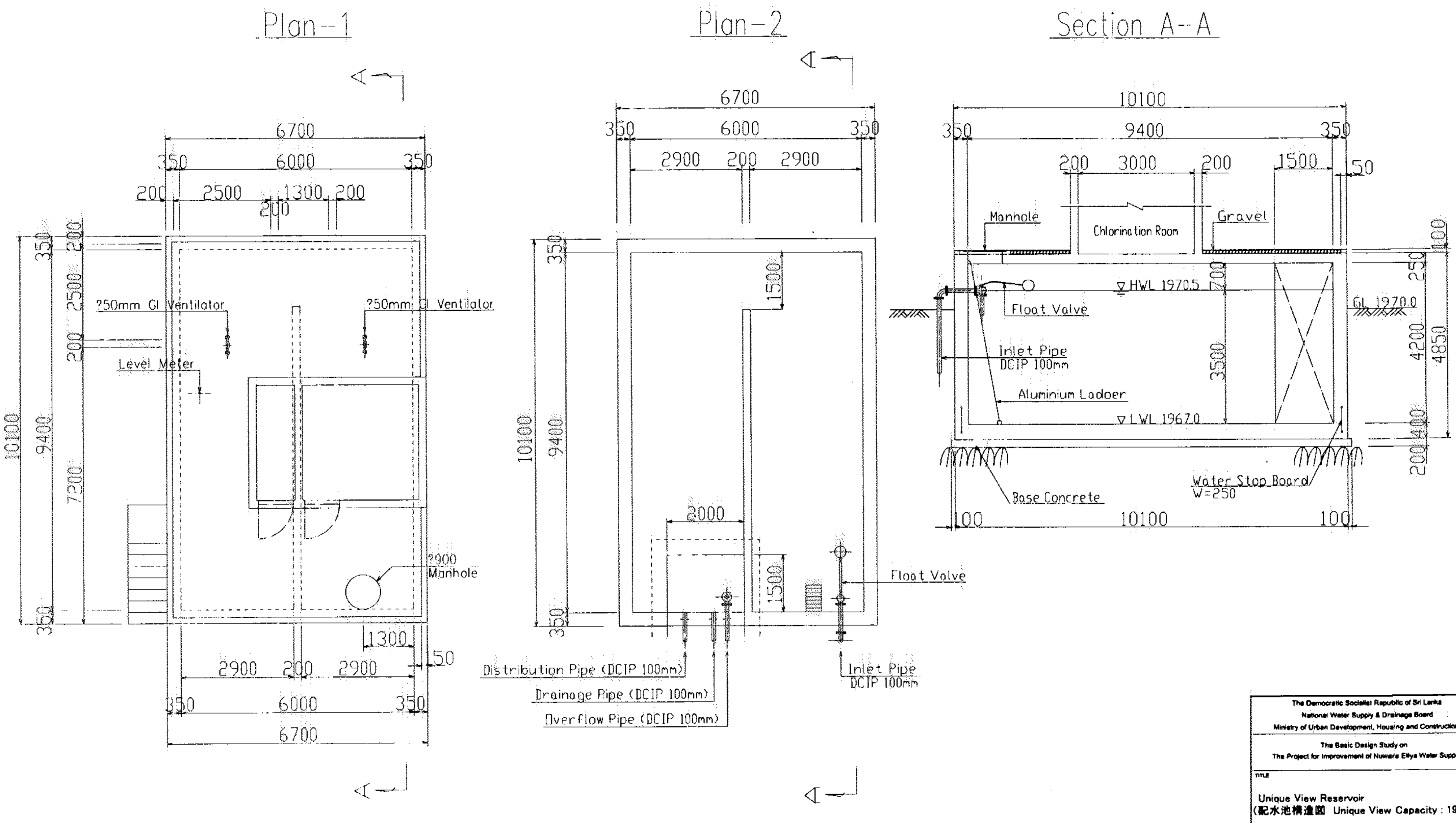
| NSC NIHON SUIDO CONSULTANTS CO., LTD TOKYO-JAPAN | Approved By / Date<br>Designed By / Date |

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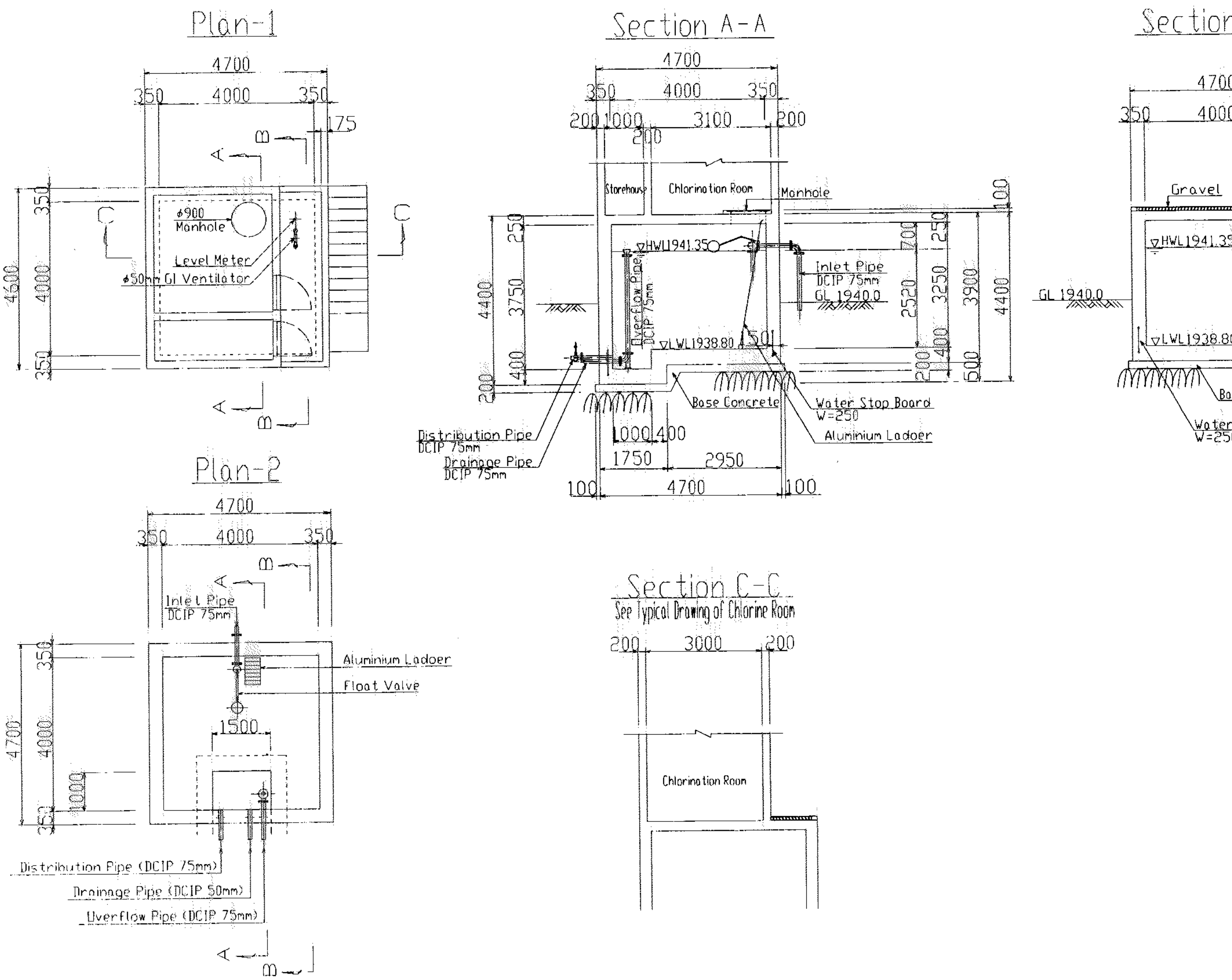
| The Democratic Socialist Republic of Sri Lanka<br>National Water Supply & Drainage Board<br>Ministry of Urban Development, Housing and Construction | |
| The Basic Design Study on<br>The Project for Improvement of Nuwara Eliya Water Supply | |
| TITLE<br>Unique View Reservoir<br>(配水池構造図 Unique View Capacity : 190m3) | |
| SCALE 1/100 | DRAWING NO Figure-2.34 |
| NIHON SUIDO CONSULTANTS CO., LTD.<br>TOKYO-JAPAN | Approved By / Date<br>Designed By / Date |

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The Basic Design Study on
The Project for Improvement of Nuwara Eliya Water Supply

TITLE
Gemunupura Reservoir
(配水池構造図 Gemunupura Capacity : 40m3)

| SCALE | DRAWING NO. |
|---|---|
| 1/100 | Figure-2.35 |

| Approved By | Date |
|---|---|
| | |
| Designed By | Date |
| | |

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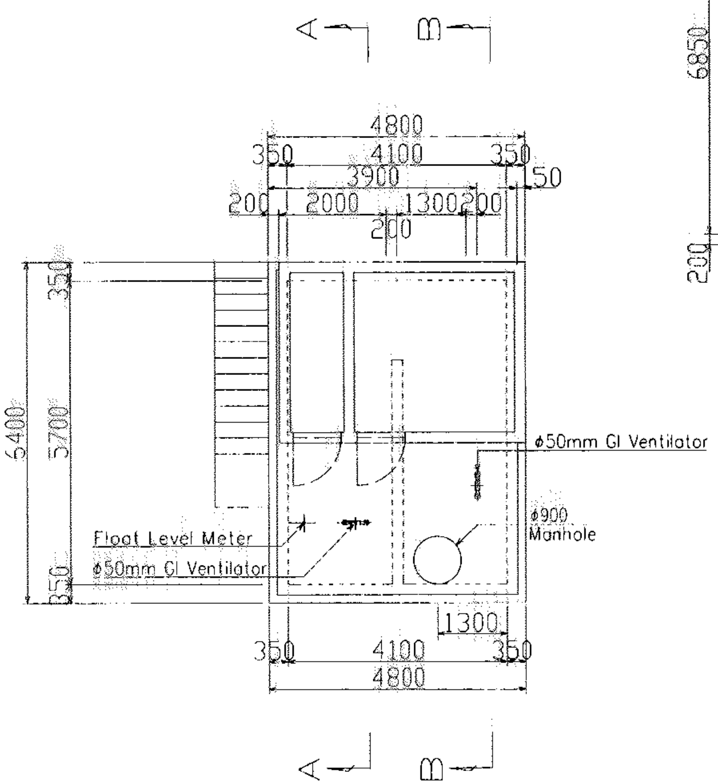
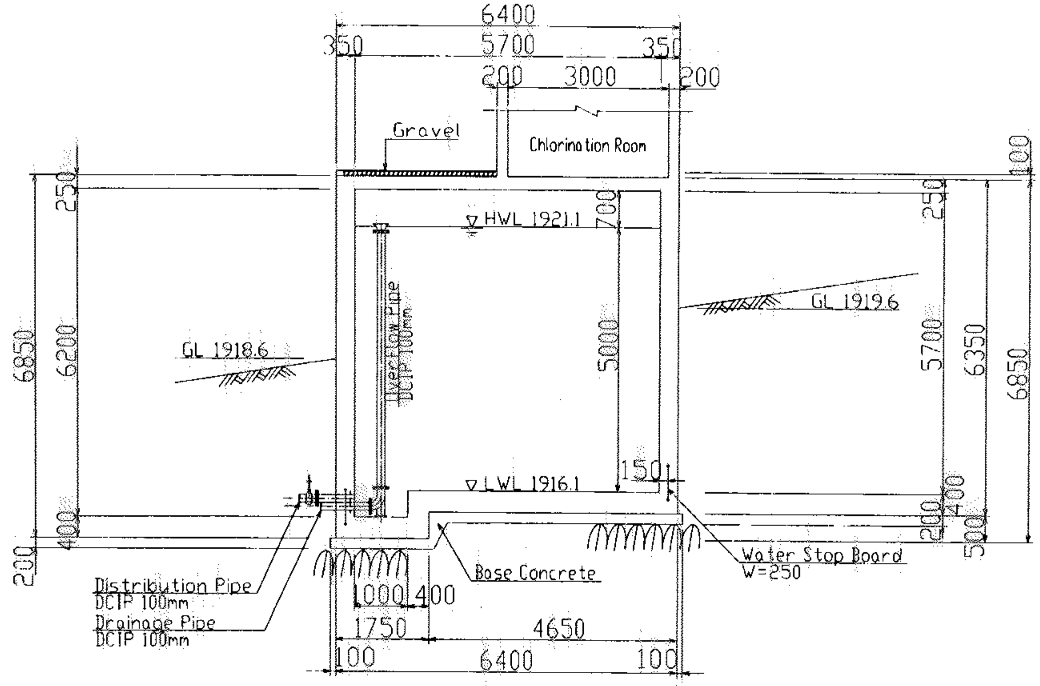
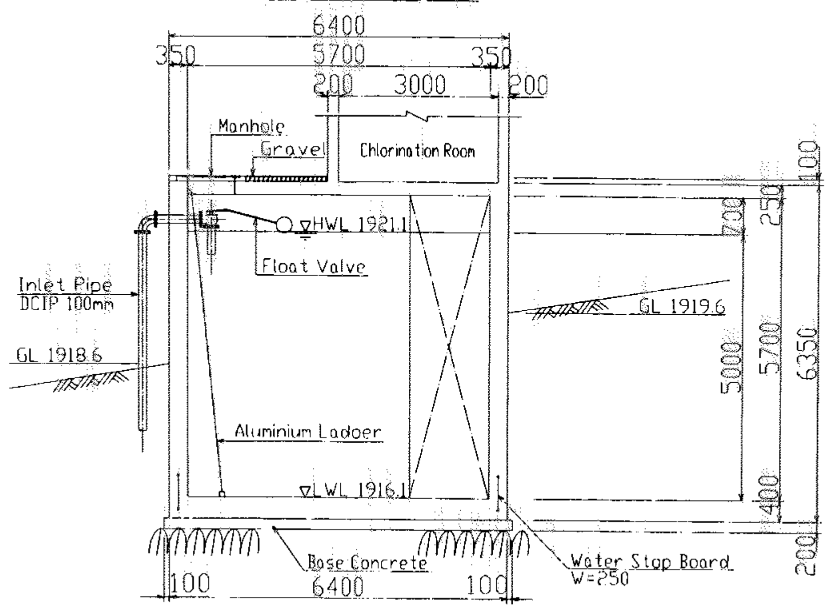
## Plan-1




## Section A-A




## Section B-B

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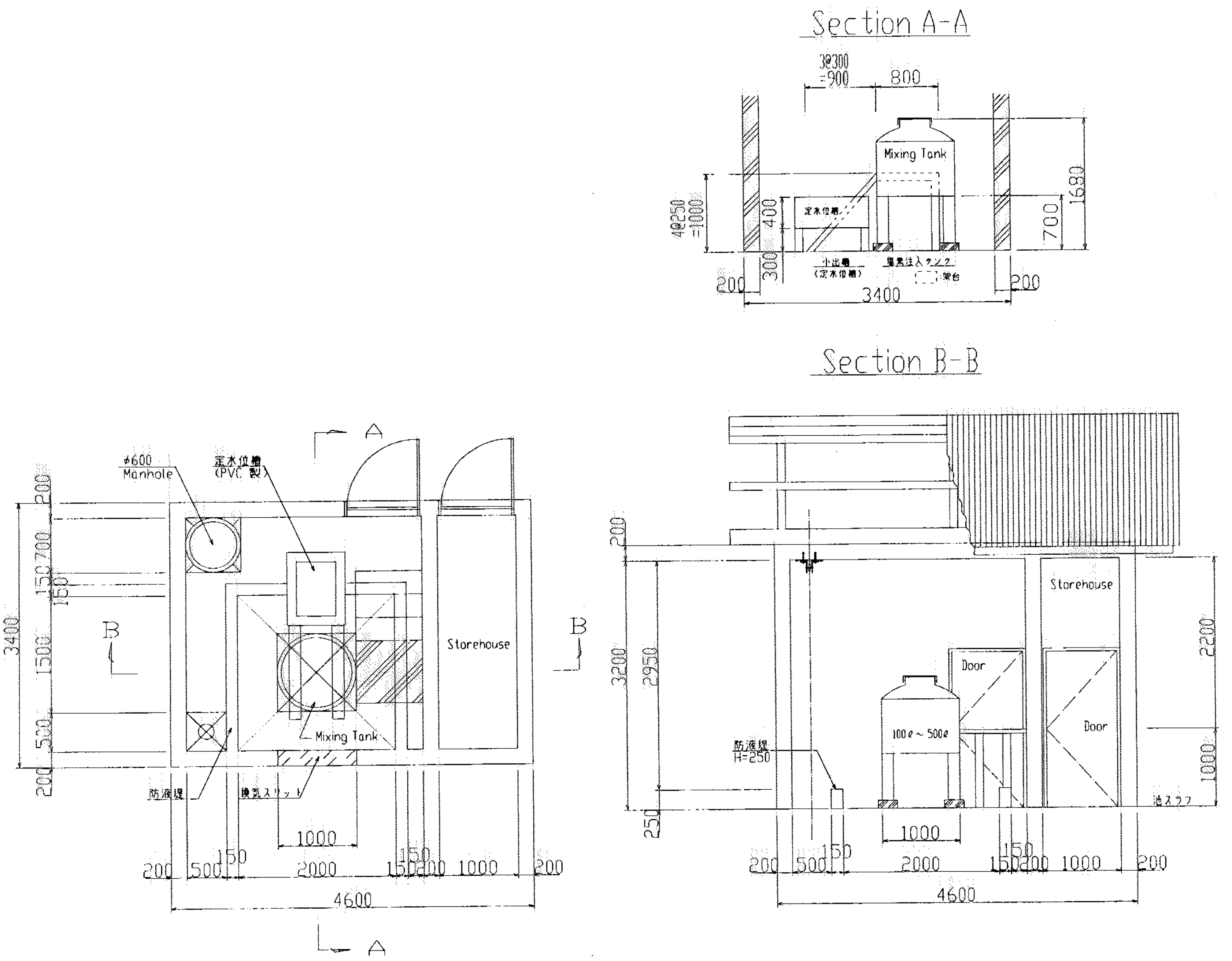
The Basic Design Study on
The Project for Improvement of Nuwara Eliya Water Supply

TITLE

Vijithapura Reservoir
(配水池構造図 Vijithapura Capacity : 110m3)

| SCALE | DRAWING NO. |
| --- | --- |
| 1/100 | Figure-2.36 |
| NSC<br>NIHON SUIDO CONSULTANTS CO., LTD.<br>TOKYO-JAPAN | Approved By / Date<br>Designed By / Date |

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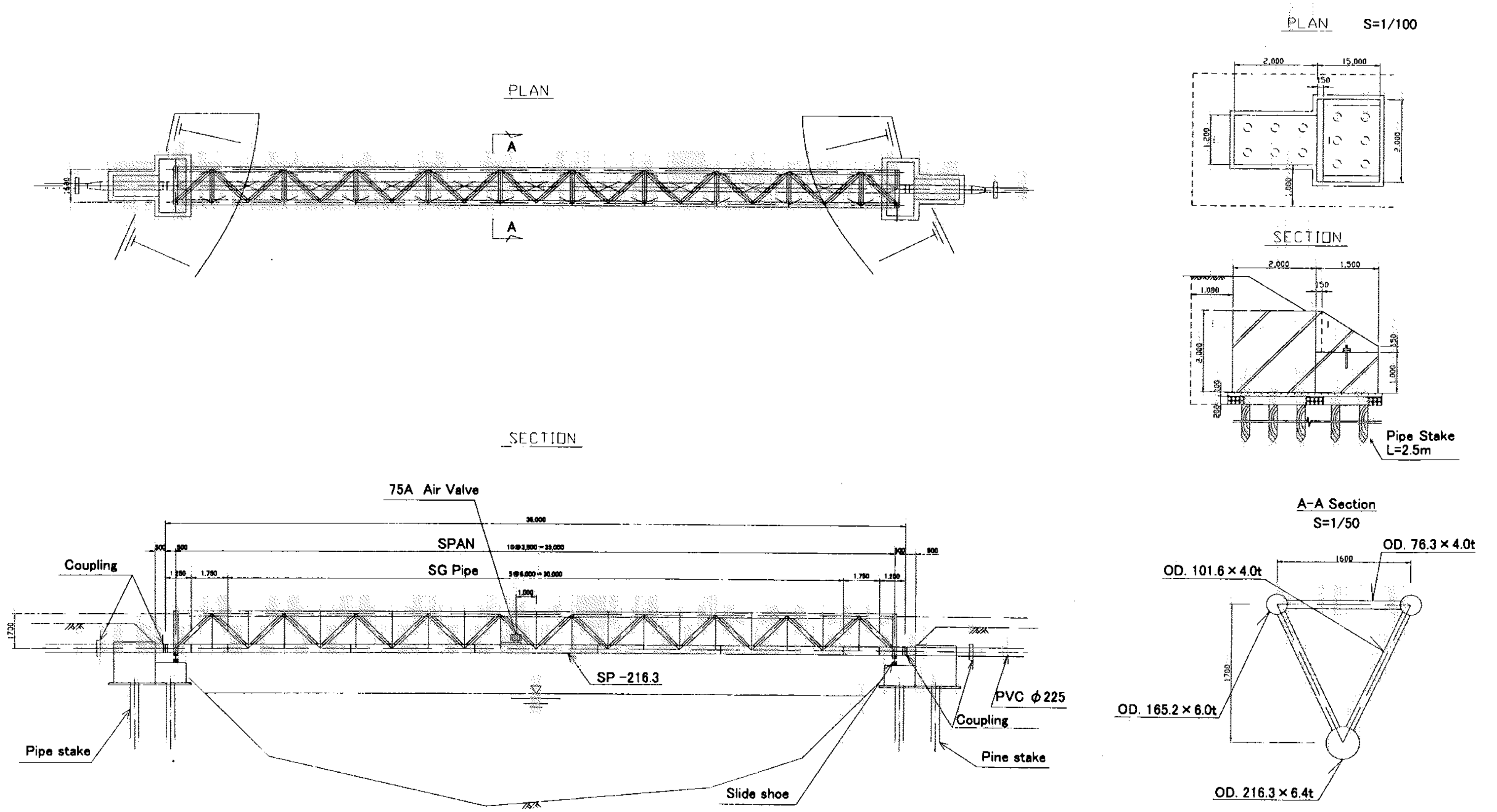
|---|---|
| The Democratic Socialist Republic of Sri Lanka<br>National Water Supply & Drainage Board<br>Ministry of Urban Development, Housing and Construction | |
| The Basic Design Study on<br>The Project for Improvement of Nuwara Eliya Water Supply | |
| TITLE<br>Chlorine Feeding House<br>(塩素注入棟 構造図) | |
| SCALE 1/50 | DRAWING NO Figure-2.37 |
| NIHON SUIDO<br>CONSULTANTS CO., LTD<br>TOKYO-JAPAN | Approved By / Date<br>Designed By / Date |

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National Water Supply & Drainage Board
Ministry of Urban Development, Housing and Construction

The Basic Design Study on
The Project for Improvement of Nuwara Eliya Water Supply

TITLE

Pipe Bridge -1
(水管橋 -1)

SCALE PLAN 1/200

DRAWING NO. Figure - 2.38

Approved By | Date

Designed By | Date

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## 2-2-4 Implementation Plan

### 2-2-4-1 Implementation Policy

#### (1) Construction

Construction for this Project will require a large-scale civil works as far as Nuwara Eliya is concerned and construction sites will be dispersed over a wide area such as for well facilities, service reservoir facilities, transmission and distribution pipeline facilities, etc. The most desirable construction arrangement shall be such that construction sites will be divided among approximately five or six local contractors *(from Colombo)* who will be operating under the Japanese Construction Contractor. It is envisaged that both construction machinery and equipment owned by local contractors and ones leased from leasing companies will be applied for construction.

Considering the expertise available with local contractors and since the Project involves construction of water retaining structures, installation of electromechanical facilities for pumps, etc. and construction of wells, etc., dispatch of technical specialists in the following areas is in dispensable.

- Japanese Steeplejack
- Japanese Formwork Technicians
- Japanese Electro-mechanical Engineers
- Japanese Well Drilling Engineers (welder, machine operator, mechanic)
- Japanese Pipe Bridge Engineer

#### (2) Construction of Wells

According to the results of soil and test boring investigation carried out in this Basic Design Study, groundwater targeted for the development in this Project is laden in the medium to hard quartzite and limestone layer approximately 35m below the ground surface. For the selection of well drilling method, one of the most important consideration is the ability to construct the well for water abstraction from aquifer consisting of medium to hard rock layer (virgin quartzite and limestone) without blocking (covering) the fragmented layer, which is collapsible when exposed to atmospheric pressure.

In the test boring investigation as well as in the Feasibility Study carried out previously, a major problem encountered in drilling test wells was drilling through brittle rock layers. 5 out of the 8 test well drilling were abandoned during the Feasibility Study, because of well walls, especially in the confined (artesian) region, collapsed after the drilling aided by artesian water pressure. Under these soil conditions in Nuwara Eliya, careful consideration is required to select well construction method for the groundwater abstraction from fractured and collapsible aquifer below 35 m from the ground,.

Three well drilling methods as listed below are the common. :

| Method | Characteristics |
|---|---|
| Percussion Method | Suitable to unconsolidated sedimentary layers and soft rocks. Not suitable to hard rocks. |
| Rotary Method | Suitable to unconsolidated sedimentary layer and rocks. Not too suitable to cobble/boulder layer. |
| Down The Hole Hummer Method | Suitable to rock mass (soft – extremely hard). Not suitable to unconsolidated/ brittle rock layers. |

Down The Hole Hammer Method is considered to be the most suitable since the soil of Nuwara Eliya is hard rock as mentioned above though it is required to apply special measures to cope with brittle rock layer for the application of this method.

It is required to insert casing pipes up to the brittle rock layer encountered during the drilling and to harden the soil by cementing for applying the conventional Down The Hole Hammer Method. After that, a smaller bit should be inserted into the casing to continue the drilling. There may be several brittle rock layers. The drilling, therefore, should be started with larger diameter in order to secure the required casing size at the bottom after reducing the bit size several times. This method also needs longer period to construct a borehole.

There is a suitable method to drill through brittle rock layers by carrying out drilling and casing simultaneously, which adopts the Down the Hole Mummer, supplementing the conventional method. The bit is extended to the larger size than the casing during excavation and it can be retracted for pulling out. Simultaneous drilling and casing in this method is reliable and has an advantage in drilling through loose overburden material, which can be found in Nuwara Eliya. Drilling can be started with smaller diameter and penetration is faster than the conventional method. Considering the above advantages and reliability, this method can be recommended for well construction in

Nuwara Eliya.

### (3) Procurement

When procuring equipment, attention shall be made to the following items.

a） Local Procurement

To facilitate easier maintenance facilities after construction, materials and equipment will be procured locally as much as possible. In this case, considering the suppliers available supply capacity will be made without adversely affecting the construction schedule.

b） Foreign (Import) Procurement

Materials and equipment, which is considered to be either inferior in quality or supply rate is not sufficient, will be procured either from Japan or from a third country. In this case, the main contractor will be required to liaise closely with Sri Lankan Implementation agencies to effect necessary import and customs clearance procedures smoothly.

## 2-2-4-2 Implementation Conditions

One of the considerations specific to construction in Nuwara Eliya is that the construction will be in mountainous terrain as well as in urban area.

Among the service reservoir construction sites adjacent to surface water source, some of them are not accessible to construction vehicles and transportation of material and equipment must depend on manual labor. In these mountainous areas, rock outcrops can be found and drilling and construction of transmission pipeline requires manual excavation of rocks. Therefore, construction plan is made considering these conditions.

Construction of transmission and distribution pipeline within urban areas must consider existing underground utilities. Therefore, test pits shall be excavated to confirm the existing underground utilities prior to installation of pipelines.

## 2-2-4-3 Scope of Works

In construction, extension of power supply facilities will be by Sri Lankan side. In this Project, facilities are designed to receive 3-Phase, AC 400 V, 4-wire type power supply. Procurement and installation of facilities required for receiving and transforming the supply to these conditions should be the responsibility of Sri Lankan side. Under the part of work to be implemented by Sri Lankan side, it is classified into procurement and installation.

### 2-2-4-4 Consultant Supervision

#### (1) Construction Management Plan

Consultant for construction supervision will carry out the following work.

1） Checking and approving the shop drawings prepared by the contractor
2） Inspection of major material and equipment prior to shipment
3） Management of construction schedule
4） Inspection after completion of construction
5） Inspection of test operation
6） Inspection of procured materials
7） Reporting of the progress of construction to Japanese and Sri Lankan Authorities
8） Technical guidance to the construction carried out under the responsibility of Sri Lankan side
9） Technical transfer for facility operation and maintenance
10） Assistance to Sri Lankan side for effecting procedures necessary when implementing Grant Aid Projects

This Project consists of construction of wells, pumping facilities and pipeline facilities, etc. For integrated supervision of construction, one resident construction manager will be placed. To facilitate supervision of specialized construction for well, etc., specialized engineering staff will be assigned as discussed in the following.

### 1) Resident Manager

Resident Manager shall oversee all construction work, monitoring the quality and progress of construction work and advise/guide the contractor as necessary. He shall report monthly to Sri Lankan side on the overall construction work. Major tasks of Resident Manager is as follows:

- At the commencement of construction, to hold a meeting with the client, the consultant and the contractor to brief and to confirm the representatives (responsible personnel) of each party, content of construction, duration of construction, etc.
- To maintain up to date records of contract documents, contract drawings, standards and specifications, survey and soil investigation results, submittals of contractor, etc.
- To review construction plan, construction schedule and shop drawings and to provide necessary recommendations and guidance prior to approval.
- To carry out inspection of materials and equipment used in the construction prior to approval.
- To supervise construction work by contractor for approval.
- To monitor progress of construction and to provide necessary advice.
- To inspect the safety of construction work and to provide necessary advice.
- To regularly conduct meetings among the client, the consultant and the contractor and as required under special circumstances.
- To inspect completed construction work for approval.
- To review as-built drawings for approval.
- To assist Sri Lankan side when handing over the completed facilities.
- To assist construction work carried out under the responsibility of Sri Lankan side.

### 2) Specialists

Depending on the progress of construction schedule, specialists will be dispatched regularly. During the test operation for commissioning, technical guidance will be provided to the local operation and maintenance staff.

#### a. Pipeline Engineer

To review shop drawings for construction of transmission and distribution pipeline, construction supervision, inspection of test operation and technical advice and guidance.

**b. Electro-Mechanical Engineer**

Review of shop drawings for mechanical/electrical facilities, construction supervision, inspection of test operation and technical advice and guidance.

### 2-2-4-5 Procurement Plan

Basically procurement of materials and equipment is either from Japan or from local sources, possibility of procurement from a third country is studied. Following are considered when deciding the sources of procurement.

- Whether quality requirements are satisfied
- Availability on quality and quantity of supply in Sri Lankan market
- Whether repair and maintenance is easier in terms of spare parts supply
- Cost

The contractor under the supervision of consultant will carry out procurement. Following items shall be considered when procuring materials and equipment.

**(1) Local Procurement**

To facilitate easier operation and maintenance after the construction of facilities, materials and equipment will be procured locally as much as possible. In this case, it is necessary to procure considering the available supply capacity without adversely affecting the construction schedule.

**(2) Foreign Procurement**

Materials and equipment, which is considered to be either inferior in quality or supply rate is not sufficient, will be procured either from Japan or from a third country. In this case, the main contractor will be required to liaise closely with Sri Lankan Implementation agencies to effect necessary import and customs clearance procedures smoothly.

However, comparing the cost of packaging, transportation and shipping, insurance, etc. for each item, if the difference is small preference will be given to local procurement.

Based on the above study, source of procurement for main material and equipment is shown in **Table-2.34**.

**Table-2.34 Source of Procurement of Material and Equipment**

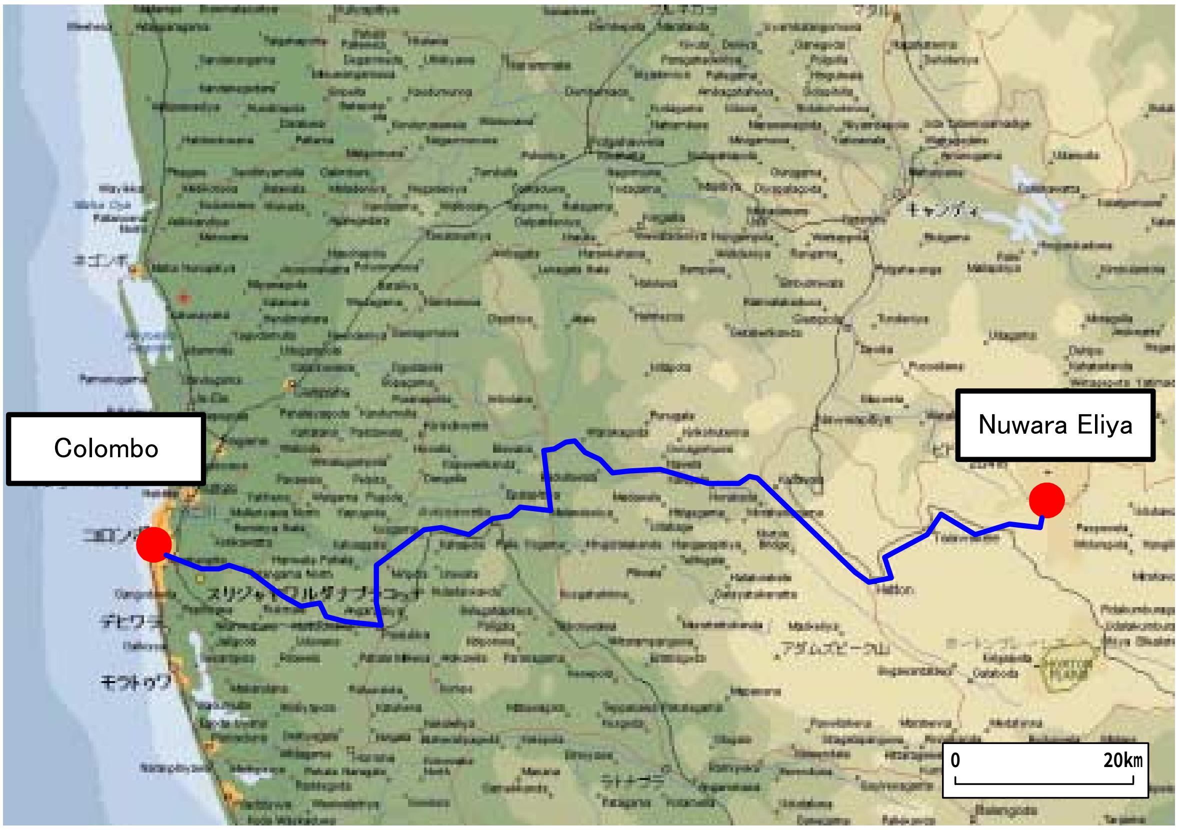
| Type of Material and Equipment | Procurement Source | | |
|---|---|---|---|
| | Local | Japan | Third Country |
| Construction materials | ○ | | |
| Construction machinery (Lease) | ○ | | |
| Pipe（PVC） | ○ | | |
| Pipe（DCIP） | | ○ | |
| Pipe Bridge Truss | | | ○ |
| Valves | | ○ | |
| Couplings | | ○ | |
| Pumps | | ○ | |
| Well Drilling Machinery | | ○ | |
| Chlorination Equipment | | ○ | |
| Water Meter for Service Reservoir | | ○ | |
| Consumer Water Meter | ○ | | |
| Meter Test Bench | | ○ | |

Cement, metal and steel reinforcement, which are the main construction materials, can be procured in Sri Lanka. These materials will be procured locally since they are available and is sufficient in quality and quantity with reasonable price. Construction machinery can be obtained on lease in Sri Lanka and is inexpensive compared to the total cost of buying from Japan or from a third country, packaging and shipping to Sri Lanka and effecting shipping procedures.

For pipe materials, PVC pipes can be procured locally without any problem of quality or quantity and their cost is low therefore will be procured locally. DCIP is not produced in Sri Lanka and considering the cost, etc. procurement will be from Japan. Procurement of pump equipment, chlorination equipment and mechanical equipment is decided to be from Japan considering operation, management and reliability.

### (3) Transportation Plan

1. Goods procured from Japan will be shipped from Yokohama Port to Colombo Port and will be transported overland to Nuwara Eliya.
2. Goods procured from third country will be shipped from the port of that country to Colombo Port and will be transported overland to Nuwara Eliya
3. Transportation routes are as follows.
   ① Japan→Colombo (Sri Lanka) →Nuwara Eliya
   ② Third Country→Colombo (Sri Lanka) →Nuwara Eliya




**Route of Inland Transportation**

### 2-2-4-6 Quality Control Plan

Quality control should be executed to secure quality which was defined and required during design.

Major quality control items are as follows.

(1) Reinforced concrete（material, mixing, placing, strength)
(2) Pipe Installation (backfilling material, compaction)

Methods and frequency of quality control for the above mentioned construction works are summarized below.

| Category | Works | Quality Control | Method | Frequency | Remarks |
|---|---|---|---|---|---|
| （1）Reinforced Concrete | | | | | |
| Steel bar | Material | Confirmation of chemical contents, mechanical characteristic, shape, dimensions, weight and these should be conform to JIS Standard | JISA-3101 | When requesting approval of materials | Mill sheet |
| Site mixed concrete | Material | salinity contain of agregate | | | |
| | Placing | Test mixing | at each plant | before placing<br>when materials are changed | deciding volume mixture ratio |
| | | Slump Test | JISA-1101 | everyday of placing | |
| | | Air contain test | JISA-1116 | everyday of placing | |
| | | Compression test | JISA-1108 | base, wall, slab, column concrete for each reservoir | X-Rs-Rm<br>data processing and managing by drawing |
| (2) Pipe Installation | | | | | |
| Backfill | Material | Soil compaction test | JISA-1210 | at the commencement of work and when soil condition is changed | |
| | Backfilling | Density of compacted soil | JISA-1214 | | |
| Road base | Backfilling | Plate loading test | JISA=1215 | | |
| Pipe material | Material | Confirmation of chemical contents, mechanical characteristic, shape, dimensions, weight and these should be conform to JIS Standard | | When requesting approval of materials | Certificate of pipe factory |

### 2-2-4-7 Implementation Schedule

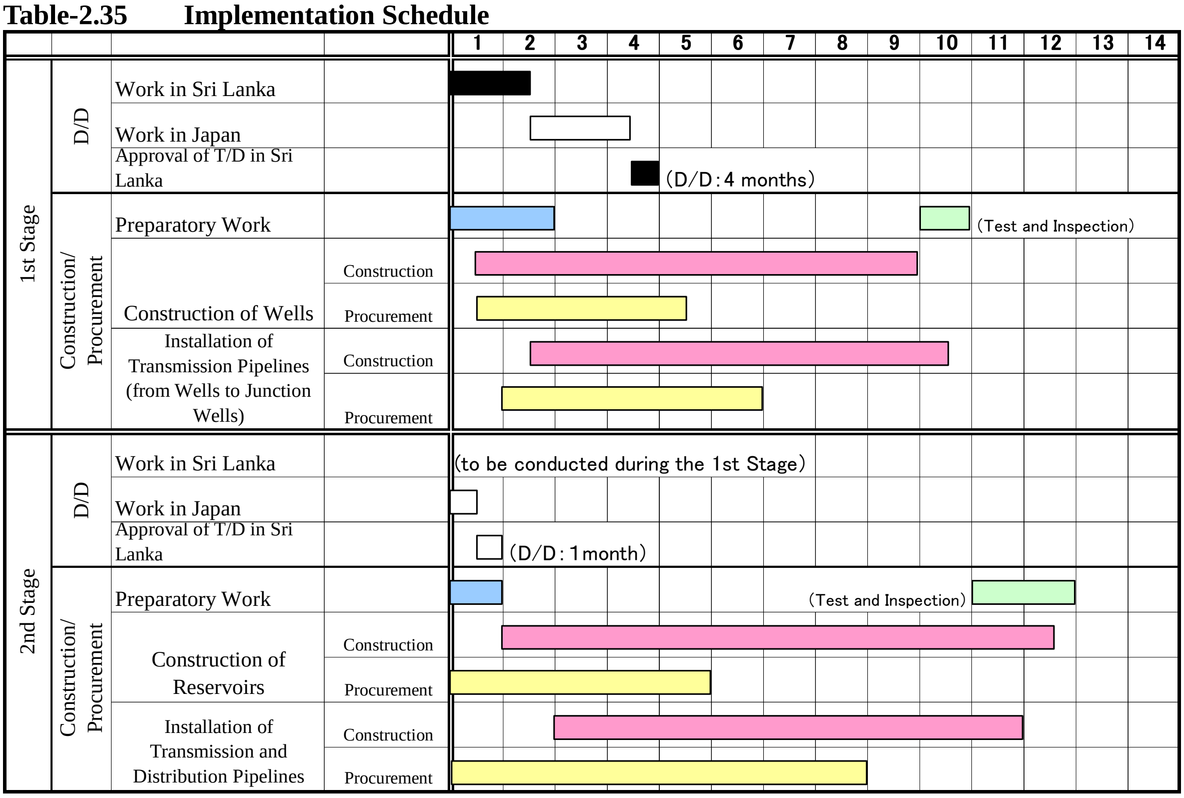
Implementation schedule of this Pro1ject will be divided into two stages.

In Stage 1, groundwater development (construction of wells) and construction of transmission pipeline from each well and junction wells will be carried out. Duration of Detailed design will be 4 months and after tendering and award of contract to the contractor, construction will be 10.0 months. Detailed design work for the Stage 2 will be conducted during the Stage 1.

In Stage 2, service reservoirs and transmission and distribution pipelines will be constructed. Duration of Detailed design will be 1 month and after tendering and award of contract to the contractor, construction will be 12 months.

Implementation schedule is as shown in **Table-2.35**.

**Table-2.35 Implementation Schedule**



## 2-3 Obligations of Recipient Country

Following components of works are considered to be the responsibility of Sri Lankan side and each of the components is described in the following sections.

1. Land Acquisition
2. Supply of Electricity
3. Replacement of Defective Water Meters
4. Implementation of Measures for Reduction of Environmental Pollution
5. Others

### 2-3-1 Land Acquisition

It is necessary that acquisition of land required for construction of well facilities (wells and junction wells) and construction of distribution reservoir facilities shall be the responsibility of Sri Lankan side. **Table-2.36** shows the location and area of required land.

**Table-2.36 List of Land to be Acquired**

| Facility | Location | Required Area($m^2$) |
|---|---|---|
| Wells 4 locations | Golf Course | 20 x 3 + 50 |
| Wells 5 locations | Hawa Eliya | 50 x 5 |
| Junction Well | Haddon Hill road (Race Course) | 200 |
| Junction Well | Hawa Eliya | 300 |
| Booster Pump | Gemunupura | 110 |
| Booster Pump | Naseby | 50 |
| Distribution Reservoir | Old Water Field | 250 |
| Distribution Reservoir | Pedro | 170 |
| Distribution Reservoir | Low Area 2 | 700 |
| Distribution Reservoir | Unique View | 140 |
| Distribution Reservoir | Gemunupura | 270 |
| Distribution Reservoir | Vijithapura | 150 |
| | Required Total Area | 2,700 |

Land acquisition required for construction of reservoirs is responsible by Sri Lanka side. According to the information from Sri Lanka side in June 2001, the land acquisition was in progress and would be completed in November 2001 before commencement of detailed design.

### 2-3-2 Supply of Electricity

Sri Lankan side shall carry out construction required for extension of electricity supply facilities. In this Study, groundwater pumping facility and booster pumping facility have been designed with the condition that they receive 3-Phase, 400 V AC, 4 wire type electricity supply. Procurement and installation of facilities required for receiving and transforming the supply to these conditions should be the responsibility of Sri Lankan side. Under the part of work to be implemented by Sri Lankan side, it is classified into procurement and installation. Location and capacity required are listed below.

| Location required power supply | Capacity Required (kW) |
|---|---|
| Wells in Golf Course | 22 |
| Wells in Hawa Eliya (for Race Course) | 22 |
| Wells in Hawa Eliya | 16.5 |
| Transmission Pump Station (Low Area 2) | 90 |
| Booster Pumping Station (Gemunupura) | 4.4 |
| Booster Pumping Station (Naseby) | 7.4 |
| Transmission Pump Station (Race Course) | 170 |

### 2-3-3 Replacement of Defective Water Meters

At present, there are approximately 800 defective water meters in Nuwara Eliya and as described previously 800 water meters will be provided for replacement. Waterworks of Nuwara Eliya shall carry out the work for replacement of water meters promptly (within about 10 months after the supply of water meters).

### 2-3-4 Implementation of Environmental Protection Measures

It is estimated that with the implementation of this Project, pollution load to the environment will be approximately 29,000 kg BOD/year due to the increase in water supply. This is estimated by multiplying increase in the quantity of water supply with the unit BOD load for pollution sources other than that of excreta (i.e. body washing, dish washing, cloth washing etc.). Compared to this, amount of pollution load that can be reduced is 51,000 kg BOD/year consisting of improvement of wastewater treatment of brewery (15,000 kgBOD/year), completion of wastewater treatment facility for General Hospital (27,000 kg BOD/year) and completion of ADB Environmental Sanitation Project (9,000 kg BOD/year) which is under planning/implementation stage. In other words, since it is possible to offset the pollution load generated by this Project to the environment by completing the abovementioned projects, it is important to ascertain that they are implemented.

In summary, to minimize environmental impact, Sri Lankan side shall implement the followings.

- For large-scale water users (brewery, general hospital etc.), an arrangement to strictly comply with effluent standards shall be made
- Effluent quality analysis and monitoring by legally entitled institution (i.e. CEA)
- Promotion of the implementation of ADB Project
- Control of fertilizer and pesticide use in agricultural farms(especially in vegetable farms)
- Strengthening of the maintenance of household septic tanks
- Water quality monitoring downstream of solid waste dumping site (Moon Plain)

### 2-3-5 Others

In addition to the items described in the previous section, Sri Lankan side shall carry out the following general items.

- Provision of facilities for power supply, water supply and drainage required for construction
- To arrange for exemption of custom duties and local taxes when transporting materials and equipment into Sri Lanka (GST: General Sales Tax and NSL: National Security Levy)
- To execute necessary procedures and the expenses associated with importing material and equipment into Sri Lanka
- To arrange for entry/exit permits and residence permits for the Japanese personnel associated with this Project
- Appropriate and efficient use and maintenance of equipment, facilities and instruments installed, constructed or granted under this Project

### 2-3-6 Cost Born by Sri Lankan Side

In accordance with the aforementioned responsible portions by Sri Lankan Side, the required costs were estimated at Rs. 12,694,800 which is composed of following cost items.

| | | | |
|---|---|---|---|
| 1) | Land Acquisition | Rs. | 8,855,000 |
| 2) | Receiving of Electric Power | Rs. | 2,639,800 |
| 3) | Replacement Defective Meters | Rs. | 1,200,000 |
| | Total | Rs. | 12,694,800 |

## 2-4 Project Operation Plan

### 2-4-1 Organization of Nuwara Eliya Waterworks

Operation and maintenance of facilities following the implementation of this Project will be by the Waterworks of Nuwara Eliya Municipal Council.

Operation and maintenance plan shall be made based on the understanding of existing problems. Following problems related to operation and maintenance were observed during the Study Team's survey in Nuwara Eliya.

- Water meter at the exit of the distribution reservoir was not read regularly,
- Chlorination facilities have not been operated continuously,
- It is necessary to classify water meters according to supply blocks,
- There are faulty or defective water meters,
- There are no facilities to check the water meters,
- Lack of personnel and equipment to carry out basic water quality analysis, etc.

To resolve the above problems with maximum self-effort by Nuwara Eliya City itself, it is necessary to restructure the organization as a water supply entity with clear allocation of duties and responsibilities. Existing organization chart of Nuwara Eliya Water Supply Department is shown in **Figure-2.39**. Hierarchy of the organization is not clear and the structure of the organization is such that duties and responsibilities associated with it are not clear as well. Number of staff in the existing Water Supply Department is 69.

In this Basic Design Study, organization chart as shown in **Figure-2.40** is proposed. In this organization, especially, responsibilities according to each distribution reservoir are assigned clearly (reading of bulk meter, continuous operation of chlorination facilities etc.). In addition consideration is given where a section where information related to non-revenue water reduction will concentrate. For the proposed organization, following the completion of this Project, required number of staff is

78 that mean an increase of nine (9) staffs. In the proposed organization, current staff shall be assigned to the key positions and the additional staff shall be assigned under them. This arrangement will pave way for on-the-job training through routine work, and the transition of reorganization and increase in staff will be in smooth condition without problems.

**Figure-2.39 Current Organization Chart of Nuwara Eliya Waterworks**

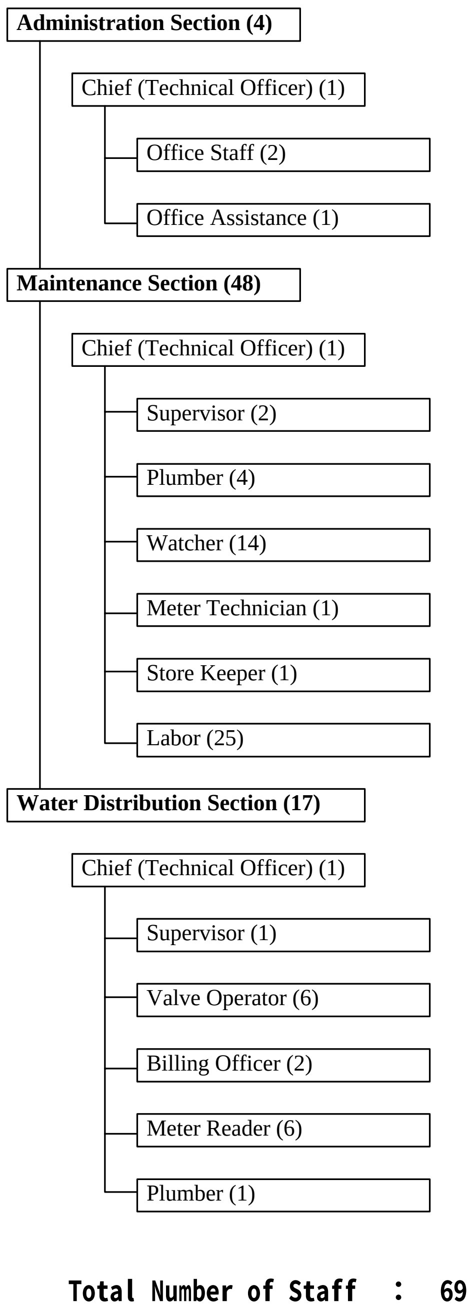
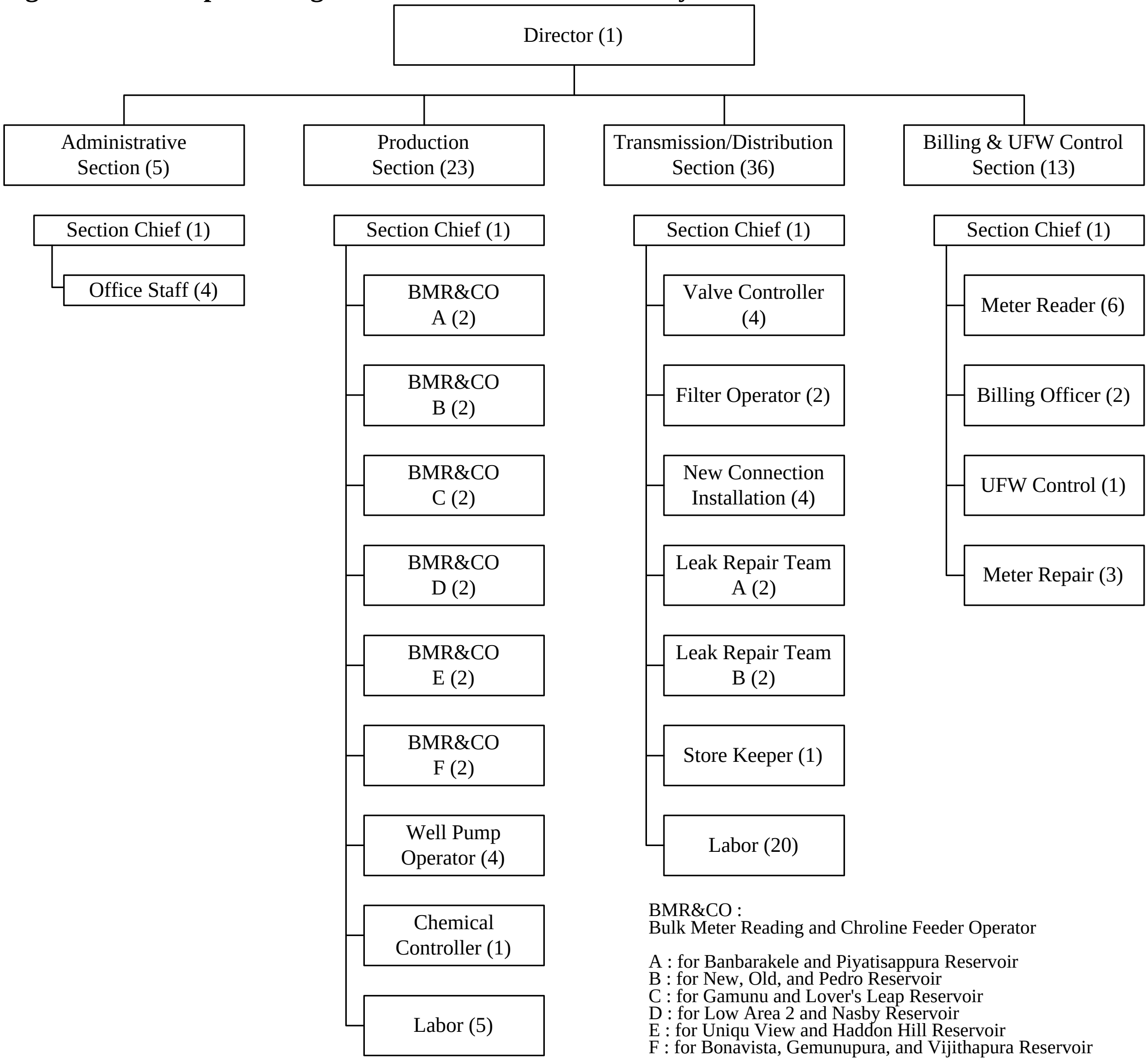


**Figure-2.40 Proposed Organization Chart of Nuwara Eliya Waterworks**




BMR&CO :
Bulk Meter Reading and Chroline Feeder Operator

A : for Banbarakele and Piyatisappura Reservoir
B : for New, Old, and Pedro Reservoir
C : for Gamunu and Lover's Leap Reservoir
D : for Low Area 2 and Nasby Reservoir
E : for Uniqu View and Haddon Hill Reservoir
F : for Bonavista, Gemunupura, and Vijithapura Reservoir

**Total Number of Staff ： 78**

In this Project, relationship between supply block and distribution reservoir is simplified and comparison of water use within the supply block and water distributed based on the bulk meter readings is made simple by way of arranging and constructing measuring facilities. In the proposed organization, new sub-sections BMR&CO (Bulk Meter Reading and Chroline Feeder Operator) are made under Production Section for each two reservoirs for clear job description and responsibility.

Under Transmission/Distribution section, two Leak Repair Teams are made to repair leakage quickly. New UFW Control Sub-section under the Billing & UFW Section will gather data of bulk meter reading and connection meter reading and it will be able to evaluate unaccounted-for water ratio in each water supply block.

Therefore, under the proposed organization, the following will become possible to implement.

- Ensuring that every meter is read and the data is accumulated
- Analyzing the data and evaluating the level of non-revenue water
- Efficient implementation of reduction measures by prioritizing non-revenue reduction according to supply blocks

Further, by clearly designating sections responsible for transmission and distribution facility and distribution reservoir, the following will be implemented.

- Continuous operation of chlorination facilities at the distribution reservoirs
- Maintenance of water meters

### 2-4-2 Operation and Maintenance Costs

Operation and maintenance costs mainly consists of wages, cost of power, cost of chemicals and miscellaneous cost. By estimating the above costs, comparison with the future water tariff in the followings.

#### 2-4-2-1 Wages

From the balance sheet of Nuwara Eliya Municipal Council for the year 1999, wages (basic salary and other allowances) for the staff of Water Supply Department is Rs. 3,726,713.00 /annum. Number of employees is 69 therefore average wages per employee is Rs. 4,500.00/month. Since, the proposed number of employees is 78 in the future, wages is estimated at Rs. 4,212,000.00/annum.

### 2-4-2-2 Cost of Power

Cost of power is mainly due to electric power required for operating pumping facilities. Cost of power required for rainy season and dry season calculated based on quantity of water and pumping heads shown in **Table-2.37**

**Table-2.37 Cost of Power**

| Pump Operation in **Rainy Season** | Q m3/day | Head m | No. of Pumps | kW /pump | Load kW | Basic Charge Rs./month | Consumption Charge Rs./month | Total Charge Rs./month |
|---|---|---|---|---|---|---|---|---|
| Transmission Booster | | | | | | | | |
| Uniqu View | 718 | 75 | 1 | 11.5 | 11.5 | 230 | 56,309 | 56,539 |
| Gemunupura | 119 | 25 | 1 | 1.3 | 1.3 | 30 | 6,595 | 6,625 |
| High Area 2 (Nasby) | 468 | 25 | 1 | 3.5 | 3.5 | 30 | 17,291 | 17,321 |
| From Junction Well to Reservoir | | | | | | | | |
| Haddon Hill | - | - | - | - | - | - | - | - |
| Gemunupura/Vijithapura | - | - | - | - | - | - | - | - |
| Low Area 2 | - | - | - | - | - | - | - | - |
| Existing Well Pump | | | | | | | | |
| Bonavista | - | - | - | - | - | - | - | - |
| High Area 2 (Nasby) | - | - | - | - | - | - | - | - |
| New Well Pump | | | | | | | | |
| Race Course from Hawa Eliya | - | - | - | - | - | - | - | - |
| Race Course from Hawa Eliya | | | | | | | | |
| Race Course from Golf Course | - | - | - | - | - | - | - | - |
| Hawa Eliya from Hawa Eliya | - | - | - | - | - | - | - | - |
| **Rainy Season Total** | | | | | | | | **80,485** |

| Pump Operation in **Dry Season** | Q m3/day | Head m | No. of Pumps | kW /pump | Load kW | Basic Charge Rs./month | Consumption Charge Rs./month | Total Charge Rs./month |
|---|---|---|---|---|---|---|---|---|
| Transmission Booster | | | | | | | | |
| Uniqu View | 718 | 75 | 1 | 11.5 | 11.5 | 230 | 56,309 | 56,539 |
| Gemunupura | - | - | - | - | - | - | - | - |
| High Area 2 (Nasby) | - | - | - | - | - | - | - | - |
| From Junction Well to Reservoir | | | | | | | | |
| Haddon Hill | 3271 | 60 | 1 | 34.4 | 34.4 | 230 | 168,460 | 168,690 |
| Gemunupura/Vijithapura | 583 | 75 | 1 | 10.1 | 10.1 | 230 | 49,454 | 49,684 |
| Low Area 2 | 1453 | 80 | 1 | 21.9 | 21.9 | 230 | 107,367 | 107,597 |
| Existing Well Pump | | | | | | | | |
| Bonavista | 193 | 60 | 1 | 3.1 | 3.1 | 30 | 15,280 | 15,310 |
| High Area 2 (Nasby) | 468 | 80 | 1 | 7.8 | 7.8 | 30 | 38,425 | 38,455 |
| New Well Pump | | | | | | | | |
| Race Course from Hawa Eliya | 667 | 55 | 1 | 8.1 | 8.1 | 230 | 39,422 | 39,652 |
| Race Course from Hawa Eliya | 667 | 50 | 1 | 7.3 | 7.3 | 230 | 35,838 | 36,068 |
| Race Course from Golf Course | 667 | 30 | 4 | 4.4 | 17.6 | 30 | 86,012 | 86,042 |
| Hawa Eliya from Hawa Eliya | 667 | 30 | 3 | 4.1 | 12.3 | 30 | 60,436 | 60,466 |
| **Dry Season Total** | | | | | | | | **658,502** |

**Table-2.38** shows the total cost of power derived from multiplying cost of power for wet season and dry season by 20% to allow for power consumption due to lighting etc.

**Table-2.38 Summary of Cost of Power**

| Item | Unit Power Cost (Rs./month) | Duration(Months) | Cost of Power (Rs.) |
|---|---|---|---|
| Cost of Pumping (rainy season) | 80,485 | 7 months | 563,000 |
| Cost of Pumping (dry season) | 658,502 | 5 months | 3,293,000 |
| Total Cost of Pumping | | | 3,856,000 |
| Others | （Assume 20% of the cost of Pumping） | | 771,000 |
| Total Annual Power Cost | | | 4,627,000 |

### 2-4-2-3 Cost of Chemicals

Cost of chemicals is for chemicals required for disinfection only. Calcium hypochloride (bleaching powder) will be used and assuming a dosing rate of 2 ppm, required quantity of calcium hypochloride is calculated as follows.

Average water demand in Phase I = 8,506 $m^3$/d

Chlorine dose concentration = 2 mg/l

$Cl_2$ Content =60%

Therefore, daily dosing rate = 8,506 $m^3$/d x 2 mg/l x 1/0.6 x 1/1000 = 28.4 kg/d

Annual dosing rate will be 10,366 kg/year. Cost of bleaching powder presently used is Rs. 1,850/50 kg which is Rs. 37/kg. Therefore, annual cost of chemicals will be approximately Rs. 400,000.

### 2-4-2-4 Miscellaneous Costs

Miscellaneous costs includes expenses for meter repair, leak repair, cost of spare parts for equipment etc. This is estimated at 1% of the cost of equipment/month. Annual cost is estimated at Rs. 3,514,000.

### 2-4-2-5 Summary of Operation and Maintenance Costs

Summary of the costs described in the previous sections is shown in **Table-2.39**.

**Table-2.39 Summary of Operation and Maintenance Costs**

| Item | Cost (Rs./year) |
|---|---|
| Wages | 4,212,000 |
| Cost of Power | 4,627,000 |
| Cost of Chemicals | 400,000 |
| Miscellaneous Costs | 3,514,000 |
| Total Operation and Maintenance Costs | 12,753,000 |

### 2-4-2-6 Revenue from Water Tariff

Average revenue from water tariff can be calculated from the total water consumption and the total revenue. **Table-2.40** shows the average water consumed and the total billing for the past three years.

**Table-2.40 Annual Water Consumption and Billing**

| | Year 1997 | | Year 1998 | | Year 1999 | |
|---|---|---|---|---|---|---|
| | Water Consumption ($m^3$/month) | Billing (Rs./month) | Water Consumption ($m^3$/month) | Billing (Rs./month) | Water Consumption ($m^3$/month) | Billing (Rs./month) |
| Jan. | 105,212 | 273,394 | 168,071 | 1,035,184 | 124,127 | 896,634 |
| Feb | 90,650 | 230,130 | 122,199 | 650,189 | 121,255 | 826,643 |
| Mar | 86,345 | 219,423 | 109,333 | 804,702 | 126,473 | 822,266 |
| Apr | 85,650 | 222,331 | 91,744 | 645,100 | 115,379 | 780,052 |
| May | 104,046 | 256,325 | 119,953 | 844,799 | 129,167 | 899,367 |
| Jun | 108,008 | 271,570 | 134,337 | 1,016,235 | 127,236 | 904,718 |
| Jul | 110,474 | 278,415 | 148,622 | 1,049,458 | 128,587 | 891,365 |
| Aug | 111,612 | 288,755 | 141,307 | 1,068,822 | 114,017 | 819,816 |
| Sep | 131,355 | 332,031 | 137,011 | 1,069,671 | 120,107 | 866,021 |
| Oct | 109,074 | 275,523 | 127,188 | 945,964 | 116,443 | 811,563 |
| Nov | 102,968 | 260,034 | 119,785 | 866,845 | 123,038 | 877,586 |
| Dec | 137,342 | 328,099 | 131,419 | 1,012,496 | 122,957 | 873,894 |
| **Total** | **1,282,736** | **3,236,028** | **1,550,969** | **11,009,462** | **1,468,786** | **10,269,923** |

Since, water tariff was revised in year 1998, billing has increased drastically from 1998. Therefore, average revenue is calculated based on the average of year 1998 and year 1999 following the revised water tariff.

**Table-2.41 Average Water Tariff**

| Year | Water Consumption ($m^3$/year) | Billing (Rs.) | Average Water tariff (Rs./$m^3$) |
|---|---|---|---|
| 1998 | 1,550,969 | 11,009,462 | 7.1 |
| 1999 | 1,468,786 | 10,269,923 | 7.0 |
| Average | 1,509,878 | 10,639,693 | 7.1 |

Average water demand in the target year 2005 is 8,506 $m^3$/d. Assuming that water tariff will not be revised, total billing will be Rs. 22,043,300/year by multiplying with the average water tariff of Rs. 7.1. However, in reality part of the billing remain unpaid and if the percentage of unpaid billing is assumed at 14.4% (according to year 1997 record) actual revenue from water tariff will become Rs. 18,869,100/year.

### 2-4-2-7 Operation and maintenance Costs and Water Tariff Revenue

Summary of the operation and maintenance costs and the revenue of water tariff discussed in the previous sections is shown in **Table-2.42** and the operation and maintenance costs can be recovered from the revenue from water tariff.

**Table-2.42 Summary of Operation and Maintenance Costs and Revenue from Water Tariff**

| Item | Amount (Rs./year) |
|---|---|
| Revenue from Water Tariff | 18,869,100 |
| Operation and Maintenance Costs | 12,753,000 |
| Net Revenue | 6,116,100 |

Account of the Nuwara Eliya Waterworks is not independent from that of the general account of Nuwara Eliya Municipal Council. When there is net revenue from water supply operation as shown above, it will be absorbed into the general account of the municipality. However, to realize stable and reliable water supply to the residents of municipality, principle of cost recovery shall be introduced; efficiency of water supply operations management improved; account of water supply department shall be separated from the general account of the municipality to transform into a self sustaining and independent entity.